Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

SHOUT
SHARE
IT

BULLETIN NO. 3.—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

THE SAN JOSE SCALE:

ITS

OCCURRENCES IN THE UNITED STATES

WITH

A FULL ACCOUNT OF ITS LIFE HISTORY AND THE REMEDIES TO BE USED AGAINST IT.

BY

L. O. HOWARD AND C. L. MARLATT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1896.

BULLETIN NO. 3.—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

THE SAN JOSE SCALE:

ITS

OCCURRENCES IN THE UNITED STATES

WITH

A FULL ACCOUNT OF ITS LIFE HISTORY AND THE REMEDIES TO BE USED AGAINST IT.

BY

L. O. HOWARD AND C. L. MARLATT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1896.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., November 29, 1895.

SIR: I have the honor to submit for publication the accompanying account of the investigations which have been made in this office during the past two years on the San Jose, or pernicious, scale.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

TABLE OF CONTENTS.

	Page.
Letter of transmittal	3
Introduction	9
Importance of the insect	9
History and present status	10
Original home and occurrence in other countries	10
History in California and the West	12
History in the East	12
Principal sources of infestation in the East	14
Summary by States of distribution and present condition	17
The probable outcome in the East	31
Relation of climate to spread	33
Habits and life history	36
Nature of the damage	36
Food plants	37
Life history	38
Descriptions of scale and insect	46
Means of distribution	49
The parasites and other natural enemies	51
True parasites	51
Predaceous insect enemies	52
A fungus disease	54
Remedies and preventives	56
Conflicting results between West and East	56
Methods of control in California	56
Methods of preparing washes followed in California	57
Formulas recommended by the division	58
The hydrocyanic acid gas treatment	59
Method of fumigating orchard trees	59
Method of fumigating nursery stock	60
Experience with remedies in the East	61
Difficulties met with	61
Value of the different winter washes	61
Soap-wash treatment on a large scale	62
Greater value of the soap wash urged	62
Desirability of a uniform grade of fish-oil soap	63
Varying results and effects of washes on tree and insect	63
Varying results on different parts of the same tree	63
Action of insecticides on dormant scales	64
Effect of the washes on the health of the tree and on fruiting	64
Behavior of different washes and their cost	65
Summary of recommendations	66
Record of experiments with winter washes	67
The nursery question	71
Legislation	72
The sale of infested fruit	74
Bibliography	74

LIST OF ILLUSTRATIONS.

		Page.
FIG. 1.	Map showing life zones and distribution of scale	34
2.	Appearance of scale on bark	36
3.	Young larva and developing scale	39
4.	Development of male insect	41
5.	Adult male	42
6.	Adult female	43
7.	*Aphelinus diaspidis* How	51
8.	*Pentilia (Smilia) misella*	52

THE SAN JOSE SCALE.

INTRODUCTION.

Since the discovery of the San Jose scale in the East in August, 1893, this insect has been the subject of almost continuous investigations by the Division of Entomology. On account of the fact that its discovery was due to this office, that its probable wide distribution in the East was first appreciated here, and that this office first called the attention of fruit growers and experiment-station workers to the great danger which it threatened, and further, on account of the fact that the insect is of national importance, State and station entomologists have looked to this office for a complete investigation of the subject. This we have endeavored to carry out, and present herewith a comprehensive summary of the results.

Much that is printed here has already been published in one shape or another in Insect Life, and republished in experiment-station bulletins and agricultural newspapers, but most of the topics of importance have been considerably added to in this publication. The most complete life history hitherto published, for example, is that given on pages 287–289, Volume VII, of Insect Life. Careful observations during an additional season have enabled us to make the present account much more complete.

The chief work which remains to be done is remedial. The writers feel by no means satisfied that cheaper if not more efficacious washes will not be found. They will continue experimental work in this direction, and in this work they count upon the cooperation of all experiment-station entomologists.

IMPORTANCE OF THE INSECT.

There is perhaps no insect capable of causing greater damage to fruit interests in the United States, or perhaps the world, than the San Jose, or pernicious, scale. It is not striking in appearance, and might often remain unrecognized, or at least misunderstood, and yet so steadily and relentlessly does it spread over practically all deciduous fruit trees—trunk, limbs, foliage, and fruit—that it is only a question of two or three years before the death of the plant attacked is brought about, and the possibility of injury, which, from experience with other scale enemies of

deciduous plants, might be easily ignored or thought insignificant, is soon startlingly demonstrated. Its importance, from an economic standpoint, is vastly increased by the ease with which it is distributed over wide districts through the agency of nursery stock and the marketing of fruit, and the extreme difficulty of exterminating it where once introduced; presenting, as it does in the last regard, difficulties not found with any other scale insect. Its importance was early recognized by Professor Comstock, who in first describing it in 1880 gave it the suggestive name of *perniciosus*, saying of it that it is the most pernicious scale insect known in this country. The Los Angeles Horticultural Commission reported in 1890 that if this pest be not speedily destroyed it will utterly ruin the deciduous fruit interests of the Pacific Coast. Its capacity for evil has been more than demonstrated since its appearance in the East, and it has been, if anything, more disastrous to the peach and pear orchards of Maryland, New Jersey, and other Eastern and Southern States than in California and the West.

We are therefore justified in the assertion that no more serious menace to the deciduous fruit interests of this country has ever been known. There is no intention here to arouse unnecessary alarm, but merely to emphasize the importance of taking the utmost precautions to prevent its introduction into new localities, and to point out the extreme necessity of earnest effort to stamp it out where it has already gained a foothold.

HISTORY AND PRESENT STATUS.

ORIGINAL HOME AND OCCURRENCES IN OTHER COUNTRIES.

Outside of the United States the insect is known to occur in Australia, Chile, and Hawaii. The inference is therefore a natural one that this insect was introduced into the United States from one of these three countries, or at least from some point in or across the Pacific. In the earlier publications on the subject it was accepted, on what seemed to be trustworthy authority, that it first reached California on trees imported from Chile by the late James Lick in 1870. This information was derived from a paper read by Mr. Alexander Craw before one of the California horticultural conventions, and Mr. Craw gave as his authority Mr. John Britton. From later correspondence with Mr. Britton it is learned that the sole bases for this supposition are (1) that the scale first became epidemic in the orchard of the late Mr. Lick, and first spread to those orchards which had communication with his orchard; and (2) that Mr. Lick was an energetic importer of trees and shrubs, and had resided in Chile for a long period before coming to California. Mr. Britton states that Mr. Lick imported trees and shrubs from other localities, and that there is no further basis for the Chilian supposition than the above.

Effort has been made to ascertain whether the insect is known in Chile, and at different times naturalists residing in that country have

been written to, and copies of circular No. 3 have been sent to each. The only definite information secured has come from Mr. Edwyn C. Reed, of Banos de Cauquenas, who writes that he has traveled a great deal throughout Chile, but has seen the San Jose scale only occasionally on pears from Santiago. The first time he met with it was in 1872, when dining with Mr. Henry Meigs, the railway contractor. The scale was noticed upon pears brought on with dessert. The pears were so badly infested that they could not be eaten, and Mr. Reed studied the insect closely and applied some washes to the trees. The significant point is *that these trees were introduced into Chile from the United States.* Mr. Meigs died shortly thereafter, and Mr. Reed has not since visited his garden. The only evidence we have, therefore, of the occurrence of the San Jose scale in Chile indicates at the same time that it was introduced into that country from the United States.

The San Jose scale occurs in Australia, but certainly not very abundantly. Mr. A. S. Olliff, government entomologist of New South Wales, reports (Agricultural Gazette of New South Wales, September, 1892) that he received specimens of it on the leaves, fruit, and twigs of pear from West Maitland, and also that though not previously reported it has been known to some fruit growers for a number of years.

Mr. Maskell informs us in a recent communication that he has received the San Jose scale on apple twigs from Mr. French at Melbourne, and also that the scale received from Mr. French on peach twigs from the same locality, and which he described under the name *Aonidia fusca* (Trans. New Zealand Institute, Vol. XXVII, 1894, p. 43), is probably identical with *Aspidiotus perniciosus.*[1] He is inclined to the opinion that this insect was introduced into Australia from Japan, stating that within the last few years many fruit trees have been imported from Japan into Australia.

Mr. Koebele, who has traveled very extensively throughout Australia, writes that personally he has never met with the species in that country, although he kept a sharp lookout for it during his last trip abroad.

In Hawaii Mr. Koebele writes that he found the scale on the island of Kauai upon prune and peach trees imported from California, some trees having been utterly destroyed by the scale and others badly infested. The importation from the United States of this insect was also indicated by the fact that many other common injurious scales of this country were also found upon fruit trees imported from California and Florida. Mr. Koebele also made examinations, at our request, for *Aspidiotus perniciosus* on the island of Ceylon, and is rather confident that it does not occur there; at least he was unable to find it.

It was surmised also that the scale might possibly have been introduced with Japanese plants, and Mr. Otoji Takahashi, a skilled entomologist, who has studied scale insects particularly with Comstock at Cornell University, was corresponded with. Mr. Takahashi has studied

[1] See *Canadian Entomologist*, Vol. XXVIII, pp. 14–16, Jan., 1896.

the scale insects of Japan since his return to that country in 1893, but reports that he has not found *Aspidiotus perniciosus*. Mr. Koebele visited Japan the past summer, and has written us twice that he has been unable to find any positive evidence of the San Jose scale in Japan, nor has he yet found it in China, as we learn from a letter from Hongkong, dated November 12, 1895.

The original home of the San Jose scale is, therefore, still a matter of considerable doubt. That it was introduced into the San Jose Valley of California about the time and at the point mentioned there can be no question, but from what foreign source it came is still to be ascertained. It may prove to be indigenous in Australia; it may have come from Japan, China, or some other portion of eastern Asia, or perhaps from some of the islands in the Pacific.

HISTORY IN CALIFORNIA AND THE WEST.

The spread of the scale from the point of original infestation in the San Jose Valley was somewhat rapid, its area increasing in every direction, but more rapidly toward the west and north. By 1873 it had become a serious pest about the point of its introduction, and in 1880 Professor Comstock found it, and, as already alluded to, indicated its extreme importance, stating that he had never seen any other species so abundant and injurious as this was in certain orchards. Mr. Coquillett reports that in 1883 it had extended as far west as San Francisco, but that in 1886 it had not reached the important fruit districts of southern California. It has now spread throughout the States of California, Oregon and Washington, reaching British Columbia in the last few years. Eastward it has extended into Idaho on the north and into Nevada, Arizona, and New Mexico on the south, also within the last few years. Some hope of relief in the future comes from the fact that in the earlier years of its appearance in California it was more destructive and more feared than it is at present. In California natural parasites have multiplied from year to year and various predaceous insects have become familiar with the scale, and, together with the parasites, have succeeded in reducing to some extent the excessive damage of earlier years. The fungous disease mentioned on a later page has also undoubtedly had a hand in this reduction.

HISTORY IN THE EAST.

The occurrence of the San Jose scale in the East was first discovered early in August, 1893, in the grounds of Dr. C. H. Hedges, of Charlottesville, Va. An infested pear had been sent by Dr. Hedges to Mr. Galloway, chief of the Division of Vegetable Physiology and Pathology of the Department of Agriculture, on the supposition that it was affected by a fungous disease. The fruit was submitted to the then Acting Entomologist, Mr. Howard, who immediately recognized the injury as due to the San Jose scale, and the startling and deplorable fact was

established of the introduction into Eastern orchards of this worst scourge of deciduous trees on the Pacific Slope, as well as the fact that it was evidently able to maintain itself in the supposedly less favorable climate of the East. The importance of this discovery was at once realized, and two agents of the division, Messrs. Schwarz and Coquillett, were detailed to make a thorough investigation. In conjunction with the State Board of Agriculture of Virginia and under the supervision of Mr. Coquillett a thorough fumigation with hydrocyanic acid gas was given to the infested trees and plants.

The introduction of the scale was subsequently traced to currant bushes purchased from a New Jersey firm.

In March, 1894, during Professor Riley's visit to the West Indies, the presence of the scale was determined by Mr. Howard at Riverside, Charles County, Md., in a rather large orchard situated on the river front, and including over two thousand peach and several hundred apple trees. The orchard was at once visited by Mr. Marlatt, who found that many of the trees were infested with the San Jose scale, large numbers having already perished. The infested stock was again in this instance traced to a New Jersey nursery. This orchard, on account of its proximity to Washington, and the facilities thus afforded for experiment, was used by the division in the testing of various washes for this scale. The outcome of this experimentation will be referred to under the proper heading. Much credit for the work is due the owner, who gave every facility for it and actively assisted in the treatments.

During the same month (March, 1894) specimens of the San Jose scale were received from De Funiak Springs, Fla., through the entomologist of the Florida Experiment Station, Mr. P. H. Rolfs.

Mr. H. G. Hubbard, one of the assistants of the division, was sent to Florida later in the spring, and at the request of the director of the Florida Agricultural Experiment Station visited the infested locality. He found the scales confined chiefly to peach and plum, occurring, however, in small numbers on Kieffer pears, pecan, and persimmon. Many thousands of trees were found to be infested, including nearly every orchard within a radius of 5 or 6 miles. The source of the infestation in this case was not definitely ascertained, but it was evident after examination that some infested nursery had sent a shipment of trees, and the indications were that there had been repeated importations, the first indication of injury having been noted six years before.

Immediately on receipt of the Florida specimens Mr. Howard concluded that as the scales had been found in three such widely separated localities, and as the information gained from the owners of two of the affected orchards led to the supposition that the original stock had been obtained from a large Eastern nursery, the probabilities were strong that the scale had established itself in many Eastern points during the preceding five or six years. He therefore immediately prepared a cir-

cular of warning, and had nearly 12,000 copies mailed early in April to all Eastern agricultural newspapers and to very many Eastern fruit growers, whose addresses were obtained through the kindness of Mr. Heiges, Pomologist of the Department. As a result of the issuing of this circular many new localities for the scale were ascertained, a widespread interest in the subject was aroused, and careful investigations were made in all the States to which there was any likelihood that the insect had been carried by nursery stock or other means.

By the end of August, 1894, the scale was known to occur in the following localities in the East: In a rather widely extended district in Florida, one locality in Virginia, three in Maryland, one in Indiana, two in Pennsylvania, many in New Jersey, and one in New York, on the east bank of the Hudson River a little below Albany. Very shortly afterwards, during the same summer, it was found on Long Island, occurring both in orchards and nurseries. Later in the fall the scale was found at three new localities in Maryland, and still later specimens were received from the extreme southern part of Georgia. In December Professor Webster reported receiving the scale from a large orchard district in southern Ohio, and a little later specimens were received from Jefferson County, Ind. The scale was also found near New Castle, Del., in January, 1895, and additional localities were found during the following spring and summer of 1895 in some of the States mentioned, and also in Alabama, Louisiana, and Massachusetts. In nearly every instance the source of infestation in the East was the same, namely, one or the other of two important New Jersey nurseries.

In the West it had previously been known in California, Washington, and New Mexico, and was especially noticed during 1894–95 in Arizona, Idaho, and British Columbia. The location of all the points of infestation will be referred to more in detail later on.

PRINCIPAL SOURCES OF INFESTATION IN THE EAST.

As stated, nearly all the Eastern occurrences of the San Jose scale were traced to two large New Jersey nurseries, from which infested stock had unwittingly been sent out broadcast for certainly six or seven years. The damage thus done to the fruit interests of the East by these nurserymen can hardly be estimated, and yet it must be admitted that they were, in a measure, blameless, since they were undoubtedly entirely unaware of the dangerous character of the scale insect which infested their stock. We can hardly avoid the conclusion, however, that they were aware that they were distributing diseased stock, since to deny this presupposes that the stock received no examination. If the scale was noticed it was doubtless supposed to be one of the common Eastern species, which, while bad enough, are of little importance compared with the San Jose scale.

In our earlier publications upon this insect we deemed it inadvisable to state explicitly the precise location of the affected nurseries, largely

for the reason that we hoped the owners would be able by prompt effort to exterminate the insect, and also because in many cases such a public statement would have brought about great financial injury to persons who had exerted themselves to place information and facilities for investigation at our disposal. With the discovery of the very wide extent of the dissemination of the scale, however, the necessity of concealment would seem to have passed away and the placing of all the facts upon record could be easily urged in the interests of the entire fruit-growing population. In the matter of nursery companies, however, the Department authorities do not feel warranted in publishing names and exact localities. As a matter of fact, however, the location and ownership of the more important nurseries have already been published in experiment-station bulletins issued by the stations of Delaware, Maryland, Ohio, New York, and Massachusetts, in agricultural journals, and in special entomological publications. Moreover, the whole San Jose scale question has been publicly discussed at many horticultural conventions, and the ownership of affected nurseries has become in this way generally known.

The two nurseries responsible for the original Eastern introduction of the scale are near Burlington, N. J., and Little Silver, N. J., the one on the Delaware River and the other near the Atlantic coast. The scale was introduced into these two nurseries in the same way. Either in 1886 or 1887, in the endeavor to secure a thoroughly curculio-proof plum, both of these nurseries introduced from California an improved Japanese variety, the Kelsey, obtained from the San Jose district. We have the statement from the proprietors of one of the nurseries that the plum trees in question were secured in the spring of 1887 from San Jose, Cal., and were shipped through the agency of a Missouri nursery company, which acted in this instance apparently as a mere transmitting agent. The trees were unquestionably thoroughly infested when received, did not thrive, and in both cases most of them were ultimately taken out and destroyed. The stock, however, had been multiplied by nursery methods, and from the original stock, and that subsequently obtained, the scale spread more or less completely throughout both of the nurseries in question.

In the case of one of the nurseries the scale spread to bearing pear trees, and from these had spread yearly to neighboring nursery trees. In the other nursery, fruit growing is quite an important feature and the scales had spread early from the introduced plum trees to bearing fruit trees, and also infested low shrubs and plants, particularly currants of both the black and white varieties. It spread finally more or less thoroughly throughout large blocks of nursery stock. Both of these firms, when the nature of the infestation was brought to their attention and the seriousness of the damage they were doing was made apparent to them, undertook measures to exterminate the scale. One of the nursury companies was particularly prompt and thorough in

its efforts in this direction, and deserves great credit for the manner in which it undertook the work; the other was for a time dilatory and seemingly indifferent, but was forced by the necessities of its business and by public opinion to adopt similar remedial measures.

The investigation of the New Jersey nurseries and of the spread of the scale in that State was undertaken by Prof. John B. Smith, the entomologist of the New Jersey Agricultural Experiment Station at New Brunswick, as soon as the danger was brought to his attention by this Department. Early in June we sent Professor Smith 1,500 copies of our warning circular. These he distributed throughout New Jersey to persons to whom suspected stock had been sent, the names and addresses having been willingly furnished by one the companies but refused by the other. The distribution of this circular, with an accompanying personal letter, in addition to a good deal of personal search on Professor Smith's part, resulted in the discovery of infested orchards in almost every county in the State. The nurseries named have a very wide market for their stock, and, as will be shown later, were the original sources of infestation of most of the points located in the East.

In addition, however, to the two prominent nurseries mentioned, there are several smaller nurseries in the East in which the scale has been found. Some of these are known to have been recently infested, and in others the infestation is of long standing and more widespread. Of the latter character, apparently, are the three nurseries located on Long Island.[1] These nurseries appear to have received their original scales from New Jersey. In one instance the proprietors made vigorous efforts to exterminate the scale, but in the others they have been negligent and indifferent in the matter, as we learn from Mr. F. A. Sirrine, one of the entomologists of the New York State Agricultural Experiment Station at Geneva. In some six other nurseries on Long Island the scale could not be found.

Prof. P. H. Rolfs stated in his bulletin on the scale that an infested nursery exists in Florida, but has not divulged its location.

In Georgia there seem to be two nurseries which have contained or have distributed infested stock. Of these, one is near Tifton, Ga., and is said to have been infected from material received from a Maryland nursery company. The other is near Waycross, and is the source of infestation in one of the Maryland orchards.

There are probably one or more infested nurseries in Louisiana, Mississippi, and Alabama, which introduced the scale originally upon Idaho pears from Lewiston, Idaho.

In Massachusetts there are infested nurseries at Cambridge and Bedford. The origin in this case is obscure.[2]

A nursery in northeastern Missouri may be infested, since the original transmission East of the infested Japanese plum was through the agency

[1] See Lintner, Bull. N. Y. State Mus., Vol. III, pp. 281–285.

[2] See Fernald, Mass. Crop Rept., August, 1895, p. 25.

of this company, and in addition the infestation at Neavitt, Md., is reported to be probably traceable to stock received from this source.

In Maryland a nursery near Mullikin was infested to a limited extent, the scale having been introduced, presumably, upon Japan pear stock received direct from California. Another, near Frederick, Md., was also slightly infested, the scale coming in on plums received from a nursery near Waycross, Ga. In both these Maryland nurseries the infested material has been completely stamped out, so far as can be determined by careful investigation.

SUMMARY, BY STATES, OF DISTRIBUTION AND PRESENT CONDITION.

The facts relating to the introduction and present distribution of the San Jose scale, by States, are as follows:

ALABAMA.

In April, 1895, Prof. J. W. Hoffman, of the department of biology of the Tuskegee Institute, Tuskegee, Ala., sent us a branch of peach for inspection which proved to be, as he feared, infested with this San Jose scale. He shortly afterwards wrote an account of the scale for The Student, a local paper, issued April 26, 1895, in which he stated that the scale was introduced on some peach trees secured by the institution from a nursery in New Jersey. He had supposed at first that it was the ordinary scurfy scale, *Chionaspis furfurus*, but on receiving the Department bulletin on the San Jose scale he gave the matter careful attention and recognized that the scale on his peach trees was the latter insect. He afterwards submitted specimens to this office for examination, and the correctness of his identification was confirmed as above noted.

ARIZONA.

Prof. J. W. Toumey, of the University of Arizona, at Tucson, reports the San Jose scale on apple, pear, peach, and apricot. How widely this scale insect is disseminated through Arizona is not known, but probably rather generally. He states (Bulletin 14, Arizona Experiment Station, June, 1895) that it has "doubtless been present in some of the older orchards of the Salt River Valley for at least ten years, where it was brought on fruit trees imported from California. * * * During the past year a number of the orchards of the Territory have suffered from the effects of this scale." He says further that the scale seems to be confined to the Salt River Valley, and mentions that no source of infestation is known outside of material coming from California. None of the State nurseries are known to harbor the pest. In Arizona the infested orchards are not numerous and the scale does not spread rapidly. In young orchards it is usually confined to the original trees, but in older orchards, where the limbs are more or less interlaced, entire orchards are in some cases badly infested.

CALIFORNIA.

The fact that the scale is at the present time disseminated throughout the State has already been indicated. In general the insect is much less dreaded by fruit growers now than it was a few years since. They feel greater confidence in their ability to control it either with winter washes or by the encouragement of natural enemies The gas treatment is very effective as shown by experiments conducted by Mr. Coquillett and others, but is not employed on deciduous trees except nursery stock. The resin washes give good results, and much also is claimed for various combinations of lime-sulphur-salt, these latter, however, proving practically valueless in the East. In some localities the main dependence seems now to be placed on the action of parasitic and predaceous enemies. These, either by artificial introduction or by the natural multiplication of native species, have become so efficient as to very materially lessen the destructive action of the scale as compared with its work in the earlier years of its occurrence. This result seems to be greatly aided by the existence of a disease which frequently almost entirely exterminates the San Jose scale and also the yellow scale.

DELAWARE.

The first report of the insect's occurrence in Delaware was sent to the Department January 15, 1895, by Dr. J. J. Black, of Newcastle. The trees affected were few in number and were young Lawson pears received from one of the New Jersey nurseries in April, 1893, and planted in a small block separated from an older orchard by a private roadway. As soon as the scale was discovered by the owner the trees of the entire block, including some replants of 1894, which seemed to be perfectly free from scales, were cut off even with the ground and burned. The owner examined the adjoining trees very thoroughly and found no scales on them, but to satisfy himself of their freedom from infestation he requested an examination by some one from this office. Mr. Marlatt accordingly visited the orchard, gave the trees adjoining the infested block a most thorough examination, and was unable to find upon them any San Jose scales whatever. The entire orchard was in a most excellent condition and showed a vigor of growth, a healthful appearance, and a care in management which are seldom seen. The example of prompt action afforded by this case, if followed by all who have infested stock, would materially aid in the ultimate extermination of the scale in the East.

A similar infestation of young stock was found in the following spring in an adjoining orchard belonging to Mr. Thomas Holcomb. The infested trees, from the same nursery, were few in number, and were in this case also destroyed.

Mr. M. H. Beckwith, of the Delaware Experiment Station, sent us in February, 1895, specimens of the scale on crab apple, from an orchard near Felton. He reported it also at Newark on some plum and peach

trees. In both instances the affected stock was from the New Jersey firms. Most of the infested trees in question have been burned and the others sprayed.

In a letter dated November 22, 1895, Mr. Beckwith informs us of the discovery of the scale at new points in the following locations in Delaware: Newark, Possum Park, Blackbird, Grubbs, Carrcroft, State Road, Port Penn, Bridgeville, and Wyoming. With the exception of the points at Port Penn and Wyoming, only from one to half a dozen trees were found infested at the localities mentioned. In about half the cases the trees have been removed and destroyed, and the others have received several treatments. Of the old localities, with the exception of the one mentioned at Newark, infested trees have been destroyed. At Newark four treatments with kerosene emulsion have been given without entirely cleansing the trees, but better results have been obtained in one instance by the use of "sludge" mixed with four parts of water and applied with a soft brush.

FLORIDA.

The Florida case at De Funiak Springs, brought to our attention in March, 1894, has already been alluded to. Mr. P. H. Rolfs, entomologist to the Florida Agricultural Experiment Station, reports (Bulletin 29, Florida Experiment Station, August, 1895) that the first orchard in which the scales were found is now practically killed out, less than 5 per cent of the trees remaining scattered over the original tract. That they were diseased was first noticed about 1888 or 1889. Several other orchards were also found to be infested, and out of 1,200 acres of orchards about De Funiak Springs 160 to 200 acres are affected. The origin of the infestation seems not to be known. Mr. Rolfs (loc. cit., p. 95), referring to the possibility of the scale occurring elsewhere in Florida, writes: "It would seem very remarkable if this were the only place in the State infested, because the nursery stock comes largely from the same places. However, only one infested place has been found, and the disease was there stamped out immediately by burning the infested trees. As this was on stock only one year from the nursery, the loss was not very heavy. The nursery that sent the stock out was visited immediately, but no trace of scale could be found on the premises. Just how the trees became infested could not be learned."

The director of the State Experiment Station, Prof. O. Clute, has taken a lively interest in the matter, and inasmuch as the infested locality at De Funiak is near the headquarters of an active fruit-growers' association, remedial work is in proper train. Dividing the expense between the station and fruit growers, California washes have been applied with care and thoroughness, and at last reports a determination existed to repeat the applications as often as might be necessary. The important consideration in the matter of extermination here lies in the fact that the infested locality is almost completely isolated

from other fruit-growing communities, this particular section being shut in on all sides by an almost unbroken pine forest extending for a distance of 50 to 100 miles, so that the chance of dissemination, now that the presence of the insect is known, is thus considerably limited, and it becomes all the more a matter of urgent necessity to exterminate it where it now occurs. The very active efforts which have been and are still being made will, it is hoped, accomplish this result.

Under date of November 19, 1895, Professor Rolfs informs us that he knows of an additional occurrence of the San Jose scale in Florida. This is below the twenty-ninth degree, or in the Peento belt, and proves to be the case at Orlando, which was reported to us by W. E. Hudson late in November, 1895. Mr. Hudson writes, under date of December 6, that the scale occurred on four trees only, two of peach and two of pear, all of which have been burned. We also learn from Mr. Rolfs that the diseased stock in this instance was obtained from Mr. James Mott, a local tree dealer at Orlando, who obtains his stock from various sources. The trees go out under his name, however, so that the nurserymen from whom the diseased trees were obtained are unknown. It seems that he obtained stock from Milford, Del.; Waycross, Ga., and from a Florida nursery, as well as from other places. A quantity of the material which the dealer in question had on hand was found to be also infested, and all of it was brought together on a brush heap and burned. Mr. Rolfs says also that he has visited the Florida nursery referred to above and made a careful inspection of the premises, and thinks that this nursery has never been infested.

GEORGIA.

The first point of infestation located in Georgia was in a large orchard in the extreme southern part of the State, as reported by the owner, Mr. L. A. Snow, of McIntyre, who submitted a portion of an infested peach limb for inspection in November, 1894. The stock, he said, was from a Maryland nursery. Under date of December 8, 1894, he reported that the scale was also introduced on his premises at Tifton on plum trees secured of the same nursery company in December, 1891. The infested trees were some fifty each of Chabot and Ogon plums. He promised to take active measures to destroy the scale and was evidently most anxious to stamp it out. The premises at Tifton were examined by Mr. Coquillett, April 25, 1895, but no scales were found nor any trace of previous infestation, the plum orchard being particularly examined.

The fact, however, that the scale is well established about Tifton, Ga., is conclusively shown by considerable correspondence with Mr. A. F. Hoffman, of Tifton, who first reported the appearance of the scale in his orchard in March, 1895, and informed us at the same time that he had destroyed all the trees on which he saw it. His orchard covers about 60 acres. Some of his stock was obtained from New Jersey and some also from Huntsville, Ala., but most of his trees are home grown. The scale had not spread very much from the point of infestation and when

the orchard was visited by Mr. Coquillett in the spring of 1895 the infested trees and also those adjoining had been dug up and no trace of the scale could be found. The fruit-growing interests in this district are large and increasing and as most of the trees were obtained from the same source the probabilities of wider infestation are very considerable. With the exception of the steps taken by Messrs. Snow and Hoffman, little, if anything, has been done to limit or stamp out the scale. We are informed that the scale probably occurs in the Fort Valley and Marshallville districts. The latter, however, was visited by Mr. Coquillett and no trace of the scale was discovered.

[Just as we are going to press specimens have been received from Mr. J. J. Mize of Pelham, Ga., upon a peach cutting from his orchard.]

IDAHO.

Prof. J. M. Aldrich, of Moscow, Idaho, states (Insect Life, Vol. VII, p. 202) that the San Jose scale is known as yet only in a limited area about Lewiston, where the oldest orchards are located. "It was introduced on trees. It is the most dreaded of all insect pests and considerable effort is made to prevent its getting a foothold in new localities."

Mr. S. S. Foote, of Middleton, Idaho, however, wrote us under date of July 12, 1894, that his orchard was badly infested with the scale, and sent specimens. He informed us in a subsequent letter (August 16) that he received the infested stock from a local nursery near Payette about five months before. He suggests that the material may have come originally from a nursery at Walla Walla, Wash. This nursery, he reports, has sold a great many trees in this and adjoining counties during the same year in which his trees were purchased, and the inference, therefore, is that the scale has been quite widely disseminated by this means. Coal-oil emulsion, resin and lye wash, and sulphur wash have been used against the scale with beneficial results. The general occurrence of the scale at Middleton is shown also in a letter dated November 19, 1895, from Mr. Jacob Plowhead, who reports that his own and some dozen other orchards in a radius of 6 or 8 miles are known to be infested. Samples of infested wood confirm his statement. He proposes to cut his trees back rigorously and apply the soap wash.

INDIANA.

The first case of infestation in this State was brought to our attention May 8, 1894, by Mr. F. A. Poindexter, of Bartle, who found the scale on two young apple trees which he had secured from New Jersey in the spring of 1891. He submitted samples of the scale to us which confirmed this identification. Promptly on discovering the condition of his trees he had them uprooted and burned. Subsequent thorough examination, which he reported June 26, failed to show the spread of the scale to any other trees, and he is convinced that he has exterminated the species in his neighborhood.

January 23, 1895, Mr. M. V. Slingerland, of Cornell University, informed us that he had just received an infested pear branch from North Madison, Ind., a locality a little east of the one referred to. The infested stock in this case was obtained from a New Jersey nurseryman in the fall of 1893.

LOUISIANA.

Mr. H. E. Weed has transmitted to us some twigs of Jefferson pear obtained from the Louisiana station at New Orleans (Audubon Park) April 3, 1895, which proved to be badly infested with the San Jose scale. A subsequent letter from Mr. Weed, inclosing one from Prof. W. C. Stubbs, director of the Louisiana station, and also letters from Mr. H. A. Morgan, entomologist of the station, indicated that the appearance of the scale in Louisiana had probably no connection with most of the other Eastern occurrences. The infested pears were of a variety which originated in New Orleans and were secured from a New Orleans nurseryman. They were set out in March, 1891. It was reported that all of the attacked trees were burned and that no further trouble was anticipated.

Our written comment upon this statement at the time reads: "This is very doubtful, however, as so complete and long-continued a case could hardly have failed to result in considerable spread." The justification of this comment was found by Mr. Howard on December 16 when he visited the grounds of the agricultural experiment station at Audubon Park, New Orleans, in company with Professor Stubbs. It was found that while the Jefferson pears mentioned had been removed, nearly all the fruit trees in the vicinity bore a greater or smaller number of scales. One or more trees of Sand pear, Bartlett, Idaho, Duchesse, and Apricot (Bonne Bouche), a Japanese plum (Hotankia) and a Marianna plum, were affected. Professor Stubbs was in doubt as to the original source of the trouble, but was inclined to think that the scales may have come from certain pear trees originally sent by a New Jersey firm to the Cotton Exposition of 1884, which were subsequently transplanted from their original position near the Horticultural Building to a little orchard at the side of Professor Stubbs's house, in the immediate vicinity of the Jefferson pears, which succumbed in 1895. Our information about the original introduction of the scale into the New Jersey nurseries, however, indicates that this did not take place until several years after the Cotton Exposition, and another source was therefore sought.

It was found that in 1891 Mr. E. M. Hudson, a prominent lawyer of New Orleans, with well-developed horticultural tastes and the owner of a beautiful place near Mobile, secured from a nursery company near Lewiston, Idaho, a large number of cuttings of the Idaho pear. There were more of these cuttings than Mr. Hudson needed for his own use, and he therefore turned the others over to Mr. G. Frotscher, a seed and fruit-tree dealer of 521 Dumaine street, New Orleans, to sell on commission. He also requested Mr. Frotscher to present two of the trees

to each of the experiment stations at Audubon Park, Baton Rouge, and Calhoun. Inasmuch as we know that Lewiston, Idaho, has long been a San Jose scale locality, it seems more than likely that this stock carried the orignal scales to Louisiana. If our surmise should prove correct, the scale will be found to have been rather widely distributed in 1891 in Alabama, Mississippi, Louisiana, and Texas. Investigation fortunately will be rendered easy, as Mr. Frotscher takes an enlightened interest in the matter and states that he will gladly allow inspection of his sales books. Messrs. Morgan and Weed will probably secure the necessary addresses at once and begin the investigation.

MASSACHUSETTS.

Prof. C. H. Fernald, of the Massachusetts Agricultural College, sent us April 25, 1895, some twigs of plum from the grounds of the Hatch Experiment Station at Amherst, Mass. These proved to be, as supposed, infested with the San Jose scale. The stock had been received the previous spring from New Jersey. None of the scales seemed to be living, but wishing to determine whether any of the insects could survive the winter at Amherst, Professor Fernald transplanted a portion of the stock to the insectary greenhouse, and early in June numerous young were swarming all over the trees. All of the affected stock was then carefully destroyed. During the early summer of the same year the scale was discovered at various points about Boston, namely, Cambridge, Bedford, and Roslindale, and also at a point southeast of Boston in Plymouth County, near the town of Scituate. All these points were seemingly traceable to a local nursery company. The information regarding these points of infestation was obtained by Mr. C. P. Lounsbury, an assistant of Professor Fernald's, who made a careful examination of the nurseries of the State under Professor Fernald's direction. The facts are detailed by Professor Fernald in the Massachusetts Crop Report for August, 1895, Bulletin 4. The occurrence at Roslindale is on plum and pear trees and a rosebush in front of a tenement house. The pear trees had been on the ground for three years and the plum trees two years, and had been obtained, as was ascertained by Mr. Lounsbury, from a local agent in West Roxbury, who claimed to have purchased them from the nursery just referred to. In April Mr. Lounsbury visited the nursery in question, finding the San Jose scale in large numbers on apple trees, and was informed that the trees were brought from an older location, where they had been growing three or four years. The latter locality was visited and peach, pear, and apple trees found badly infested, many of them already killed. No stock had been added to the old nursery for three years, indicating the occurrence of the scale there for at least that time, and probably much longer. The original source of the infested stock could not be learned.

The occurrence at Scituate is in the apple orchard of Mr. E. E. Cole, who informed Professor Fernald that his orchard of 90 trees was

set out some three years ago, the stock having been obtained for the most part from the nursery company near Boston already discussed. The orchard is located in a protected situation, with trees on three sides, and is within 2 miles of the ocean.

These Massachusetts occurrences are of especial interest, in view of their bearing on the probable northward extension of the San Jose scale. The facts, taken in connection with others, seem to indicate an upward extension of the temperature belt, in which the scale can establish itself, to include at least the Connecticut Valley as far north as Amherst, and perhaps a coast strip extending somewhat above Boston.

MARYLAND.

The occurrence of the San Jose scale has been determined at the following points: Neavitt, Chestertown, Riverside, West River, Sharpsburg, Frederick, Still Pond, Mullikens, T. B., Charlton Heights, and Linkwood.

Neavitt.—The occurrence at Neavitt, Talbot County, is in an orchard of some 14 acres, belonging to J. H. Reip, on an inlet of Chesapeake Bay, and was brought to our attention May 19, 1894. The orchard is mainly of peach trees, with some 4 acres of apple, cherry, plum, and pear trees. Practically all the trees are infested with the scale. The age of the trees is from 1 to 8 years. The source of infestation is said to have been trees received from the Missouri nursery already referred to; but as stock was received from other nurseries, this conclusion is by no means certain.

Chestertown.—The occurrence of the scale at Chestertown is in the orchards of Mr. Robert Emory. It was found there in July, 1894, by Mr. Marlatt, while making some studies on another pear insect. The insect was brought in with some two or three hundred pear trees secured from one of the New Jersey nurseries in 1890. From this stock the scale has spread to adjoining pear orchards. It is most fortunate for the neighboring fruit growers that the owner of this infested stock is an exceptionally able and energetic man, and proposes to leave nothing undone to exterminate the scale. In the fall of 1894 he, unaided, applied an expensive whale-oil-soap winter wash to every suspected tree, and has now (December, 1895) concluded a second treatment, in which he used over 7 barrels of soap. This last treatment was for the most part at the rate of 2½ pounds of soap to the gallon of water, and, as evidenced by numerous twigs exhibited at the January, 1896, meeting of the Peninsula Horticultural Society at Denton, Md., had resulted in the complete extermination of the scale. Mr. Emory deserves the credit for having called original attention to the merits of this simple soap wash when used against this particular scale. Its general and very great value against scale insects, however, had already been established by Comstock in 1880. (Ann. Rept. Dept. Agric., 1880, pp. 286, 287.) The year following the planting of the New

Jersey trees Mr. Emory had noticed their diseased condition, and had an employee go over the ones most affected with a "thick whale-oil soap of the consistency of molasses." This treatment was perfectly effectual. Examination of one of these trees showed that it was perfectly clean nearly three years after treatment. The owner of the orchard was rather prejudiced in favor of the whale oil-soap treatment, and a very strong wash was then given a young pear tree to further substantiate its efficacy. The good results shown by the old treatment and obtained in this new experiment led to the more careful work with soaps conducted by the Department at Riverside, which ultimately established the superior merits of soap washes of proper strength as winter remedies.

Riverside.—At Riverside the infested orchard is on the bank of the Potomac River, in Charles County, Md., on the place of Mr. E. Dows, and the fact of its infestation, as already described, came to our knowledge in March, 1894. The orchard covers about 20 acres, and consists chiefly of peach trees, with which, however, are intermixed some apple trees. The infested stock was received in 1887 from New Jersey, planted in the spring of 1888, and from this practically the entire orchard has been infested, many of the trees having already perished, including most of the original infested stock.

When this point of occurrence was first discovered, the neighboring orchards were, as far as could be determined, entirely free from scale. In October of this year (1895), however, it was found that two vigorous young peach orchards a mile to the south, belonging respectively to Mr. Robert Marbury and Mr. Swan, were also infested in spots with the scale, together with a few peach trees on the river intermediate between the Dows farm and the orchards last mentioned. The stock of the latter orchards was obtained from a Virginia nursery, and the trees were unquestionably healthy when first received. The scale has evidently been carried to them by birds or insects from the Dows orchard.

West River.—It was learned April 25, 1895, that some Japanese quinces received from a New Jersey nursery, and growing on the place of Mr. N. S. Chew, at West River, Anne Arundel County, were infested with the scale.

Sharpsburg.—This locality was brought to our notice by Mr. Joseph H. Cox, who sent specimens of diseased peach trees to Professor Robinson, of the Maryland Experiment Station, who submitted them to this office for determination December 2, 1894. Mr. Coquillett was sent to this locality March 15, 1895. The orchard was found to be situated 3 miles northwest of Sharpsburg, on the Potomac River, and to contain 9½ acres of 4-year-old peach trees obtained from a nursery near Frederick, Md. The scale seems to have been introduced with a particular variety, which was planted in the center of the orchard, and from this point had spread more or less outward.

An additional locality at Sharpsburg was brought to our attention

by Charles G. Biggs. He writes, November 30, 1895, that the scale has made its appearance in the orchard of Biggs & Showman, 3 miles south of Sharpsburg. The orchard contains about 10,000 trees, only 30 of which were affected, so far as he could determine by critical examination. At the request of the owners of the orchard, Mr. Coquillett visited the locality January 13, 1896. The scale proved to have been introduced on peach trees of the variety "Wonderful" from one of the New Jersey firms, and had spread considerably from the original infested stock, so that in all upward of a thousand trees bore scales. Some of the worst infested trees had been dug up and burned. Those remaining were only scantily covered with scales, and no material injury has been done up to the present time. The owners proposed immediately to spray the entire infested tract with whale-oil soap, using it at the rate of two and a half pounds to the gallon. This orchard is in the midst of the mountain peach district of Maryland, and lies on the western slope of a spur of the Blue Ridge Mountains.

Frederick.—The infested nursery near this place was visited December 27, 1894, and the San Jose scale was found on some plum trees said to have been obtained the April previous from a Georgia nursery. None were found on other nursery stock or fruit trees near by. We were informed also that the scale occurred on trees in the orchard of John A. Nicodemus, of Edgemont, Md. At a later examination of the nursery near Frederick, Mr. Coquillett was unable to find any further indications of the scale, the stock originally attacked in the meantime having been uprooted and destroyed.

Still Pond.—The Still Pond occurrence was in the orchard of Mr. James S. Harris. It was first noticed in April, 1891. The trees were burned at the time, and the owner believes that there is now no scale on his premises. The correct identification of the species in this case is not vouched for, as the material was destroyed and no opportunity for examination afforded.

Mullikin.—The infestation near this point, in a local nursery, was investigated by Mr. Coquillett December 21, 1894, and seems to have originated with certain Japan plums brought from California. The owners showed a praiseworthy energy, and immediately uprooted and burned the infested stock. This nursery was again visited by an agent of the division, in November, 1895, who made a most careful inspection. Two slightly infested trees were found, and these were immediately destroyed.

T. B. Post-office.—The infestation at T. B., Prince George County, was brought to our attention in August, 1895, by Mrs. E. L. Nixon. In this case there were about 20 trees badly affected and as many more slightly so—a number of the worst affected having died. The stock was purchased from the nursery near Mullikin, Prince George County, and planted in the spring of 1891. The owner proposes to grub up the worst trees, severely prune others, and afterwards treat them with washes.

Linkwood.—Mr. Robert Gulick exhibited twigs infested with the scale from his place at Linkwood, Md., at the meeting of the Peninsula Horticultural Society January 17, 1895. He informed Mr. Marlatt that his stock came from a number of nurseries, including the one in Missouri previously alluded to and others in Maryland.

Charlton Heights.—Mr. J. C. Brelsford found the scale in January, 1896, on a single plum tree, bought in 1894 from a Baltimore firm. The insect had not spread to adjoining trees, and the original tree was dug up and brought to the insectory of the Department for experimental use.

NEW JERSEY.

From New Jersey the original distribution to most of the Eastern localities was made by the two nurseries already referred to. The manner of introduction of the scale into these nurseries has already been discussed. As would naturally be supposed the points of occurrence are much more numerous in New Jersey than in any other Eastern State. They have been located by Professor Smith in nearly every county in the State, the only immune district being in the northwestern corner of the State. The number of localities actually ascertained reaches upward of 100. In fact, the occurrence of the scale in New Jersey orchards is so general that it has not been deemed necessary by Professor Smith to put the individual localities on record.

Professor Smith thinks that he has located most of the points at which the insect exists, and has urged upon the owners the supreme necessity of stamping it out if they wish to retain their orchards. In every case willingness has been expressed to do all in their power to destroy the pest, and often the infested stock has been uprooted and burned. In other cases thorough spraying has been given the affected trees.

The results so far obtained, however, are far from satisfactory, and in letter dated January 13, 1896, Professor Smith reports that in south Jersey orchards matters are much worse than they were a year ago.

NEW YORK.

The occurrence of the scale in New York was first determined in August, 1894. The exact locality was the orchard of Mr. L. L. Morrell, at Kinderhook, a short distance below Albany, on the Hudson River. The scale was there found on apple and pear trees obtained from one of the New Jersey nurseries, and the infested stock was promptly uprooted and burned. Later in the same year a number of points of occurrence were found on Long Island by Messrs. F. A. Sirrine and V. H. Lowe, of the Geneva Agricultural Experiment Station. The history of the discovery of the scale on Long Island was reported in Garden and Forest of November 7, 1894. It was first observed by Mr. Sirrine in the market of Jamaica on some Bartlett pears said to have been grown on the island, and also on some pears exhibited at the Queens County Fair. On tracing the fruit to its source some of

the infested orchards and nurseries were located, the scale being found on pear, apple, peach, and quince stock. No less than three nurseries on Long Island were found to harbor the San Jose scale. The source of the scale in these nurseries was at first obscure, but it was later learned that one of them, at least, has been getting stock from the contaminated New Jersey nurseries for a number of years. A very thorough effort has been made to exterminate the scale in one of these nurseries, but the other two nurseries did not take the same prompt action, although they may have entered upon the work of extermination during the summer of 1895. In view of the failure of certain of these nurseries to take immediate action toward the eradication of the scale, a bill was drafted by Dr. Lintner and presented to the legislature of New York at its last session to admit of the enforcement of the necessary remedial operations. The text of the bill, the passage of which has not been effected, is given on p. 73.

Dr. Lintner informs us under date of November 28, 1895, that the passage of this bill will not be urged during the coming session of the State legislature, since he is inclined to think from recent experience that New York is not likely to have any serious trouble with the scale.

The scale has also been discovered at Jamaica, Long Island.

The presence of the scale was reported by Dr. Lintner, April 27, at New Milford, Orange County, near the boundary between New York and New Jersey. The information came from Mr. Slingerland that it was present on a single tree received from New Jersey. The large nurseries at Rochester and Geneva were examined by Messrs. Sirrine and Lowe and found to be untainted.

NEW MEXICO.

The occurrence of the San Jose scale in New Mexico was first learned from specimens received from Prof. C. H. Tyler Townsend, on quince, April 29, 1892. In Bulletin 7 of the New Mexico Experiment Station, June, 1892, Mr. Townsend records the species at Las Cruces upon apple, pear, plum, peach, quince, and rose. Prof. T. D. A. Cockerell, in The New Mexican of July 11, 1895, states that this insect, originally limited to the Mesilla Valley, has, within the last few weeks, been found also at Socorro and at Bernalillo. The scale is well established about Las Cruces and is more or less distributed throughout the Mesilla Valley. At Socorro it is confined to a few trees in the town, where it was brought directly from California. At Bernalillo the scale seems to have been present for some time and is more widely disseminated. The original introduction has occurred in all cases upon California stock.

OHIO.

The occurrence of the scale in Ohio was first brought to our attention December 19, 1894, by Prof. F. M. Webster. The first locality was in Clermont County, on the Ohio River near New Richmond, in the apple orchard of Mr. Thomas J. Nichols. The stock was secured in 1890 from

New Jersey. About 50 trees in the middle of an orchard of 600 were reported to be thoroughly plastered with the scale. Nearly the same number were more or less affected. A smaller orchard set at the same time and with trees from the same nursery was widely but not heavily infested. The owners of both places have promised to take vigorous steps to stamp out the scale.

Information of a second Ohio case came to us from Mr. F. A. Sirrine, of Jamaica, N. Y., February 19, 1895. Mr. Sirrine transmitted to us some infested twigs for identification which he had received from Dr. J. McCann, of Delaware (orchard at Irville?), Ohio, who wrote that the trees were purchased five or six years before, in part from one of the New Jersey nurseries, and the balance in Ohio.

A third point in Ohio was reported by Professor Webster, March 1, 1895, in Muskingum County, in an orchard of 4,000 trees set out five years before.

Under date of November 16, 1895, Professor Webster reports three additional localities for the San Jose scale in Ohio. He writes: "The localities in Ohio where we know the San Jose scale to occur or to have occurred are as follows: New Richmond, Silverton, London, Irville, Duncan Falls, Neffs. The first and by far the worst outbreak is being handled with an energy that deserves the highest commendation; the second is not being managed so carefully, and the third is exterminated, I believe. The fourth, the same that Sirrine refers to, is being taken care of properly, while of the other two I only know that the affected trees were promptly destroyed."

OREGON.

The San Jose scale occurs pretty generally throughout the eastern fruit belt of Oregon and also extends up the Columbia River. It has been definitely located at the following points: Hillsdale, Corvallis, Umpqua Ferry, Salem, Portland, Milwaukee, Rocky Point, and The Dalles. The conditions are very similar to those prevailing in California.

PENNSYLVANIA.

The scale has been located at the following points in Pennsylvania: Atglen, Lewisburg, Waynesboro, Bristol, Marietta. The locality at Atglen was visited by Professor Smith, who found that in an orchard of over 7,000 trees all of certain varieties were infested with the scale. As a result of his recommendations, kerosene emulsion has been applied three times to most of the trees, at intervals of ten days, up to the first week in June. The treatment was reported absolutely successful.

The occurrence at Lewisburg, Union County, is in the orchard of Dr. G. G. Groff, of the State board of health, professor of chemistry in Bucknell College. In 1890 some pear trees were purchased from one of the nurseries in New Jersey, which proved to be badly infested. This orchard was visited by Mr. Howard in October, 1894. It is a small one, and the owner hopes to eradicate the scale by careful treatment.

In February, 1895, Mr. E. B. Engle, of Waynesboro, transmitted scale-infested twigs secured from the premises of Mr. Jacob Lester, near Waynesboro. The trees were reported to have been secured from a Maryland nursery company a few years before. The scales seemed to be chiefly confined to plum trees planted four years ago. From these, however, it was afterwards found to have spread to an osage-orange hedge near by, which was very badly infested, domonstrating that the San Jose scale would thrive on this unsuspected food plant. Mr. Lester proposed to spray vigorously. Under date of January 7, 1896, Mr. Engle writes us that Mr. Lester applied whale-oil soap the previous spring with very satisfactory results and almost exterminated the scale both on his plums and on the hedge.

At Bristol, as we are informed by Mr. C. Taylor Knight under date of February 6, 1895, the scale was introduced upon a dozen Japan plum trees purchased from one of the New Jersey companies three years before. From these it has spread to adjoining pears and plums, affecting about thirty trees in all. Many of these trees have been uprooted and burned and others sprayed with whale-oil soap and kerosene emulsion.

VIRGINIA.

But two points of infestation have been located in this State, namely, the one at Charlottesville already referred to and another at City Point. The orchard of Dr. C. H. Hedges at Charlottesville, where the scale was first located in the East early in August, 1893, is a small one, situated about a third of a mile from the center of the town, and contains chiefly dwarf pear trees, with, however, various other fruit trees and raspberry and currant bushes. The currants and the pear were the plants chiefly affected, and, as afterwards learned, the scale had been introduced on these, particularly the currants, about 1890, with stock obtained from one of the New Jersey nurseries. A thorough treatment with hydrocyanic acid gas was given to the orchard in March, 1894, under the immediate and skilled supervision of Mr. D. W. Coquillett. The operation was as thorough as it could be made. That a few of the insects survived the treatment, however, was shown by the receipt of living specimens late in the fall of the same year from Dr. Hedges. The State Board of Agriculture was informed concerning this condition of affairs and made an appropriation of $100 for the purpose of conducting a final campaign during the winter of 1894–95.

The spraying operations were inadequately conducted, however, and inspection in the late fall of 1895 showed that only temporary relief had been gained. The existing state of affairs was brought to the attention of the State authorities, and we were informed by the commissioner of agriculture of Virginia January 13, 1896, that the State legislature proposes taking some action on the subject of the San Jose scale.

The other locality, which is on the James River in Prince George County, was reported to us June 26, 1895, by Prof. W. B. Alwood,

entomologist of the State Agricultural Experiment Station at Blacksburg. We have not seen specimens, but rely on Professor Alwood's identification.

Under date of November 19, 1895, Professor Alwood reports further of the locality at City Point that the outbreak proved to be of a very serious nature, about 1,800 trees being involved, many of which were entirely ruined before the nature of the injury was discovered. Following his advice, caustic and soap washes were applied as winter remedies, and soap washes and emulsions as summer applications, with the result that when visited in July of this year there was scarcely a live scale to be found.

WASHINGTON.

The scale is probably pretty well distributed through the settled districts of Washington, although but two definite localities are recorded, namely, Walla Walla and Tacoma. The occurrence at Walla Walla was brought to our attention in 1890 by Mr. William M. Freeman, who wrote that the orchards of Mr. J. M. Gose at that place were affected (Insect Life, Vol. III, p. 68).

WEST VIRGINIA.

Under date of January 31, 1896, Mr. A. D. Hopkins, entomologist of the West Virginia Agricultural Experiment Station, reports that he has located the San Jose scale at two places in West Virginia, viz, near Wellsburg, Brooke County, some distance above Wheeling, and at Georgetown, Monongalia County, near the Pennsylvania line. The scale was introduced at both places on stock from New Jersey nurseries.

BRITISH COLUMBIA.

Specimens from British Columbia were sent us by Mr. James Fletcher May 15, 1894.

THE PROBABLE OUTCOME IN THE EAST.

It will be seen from the foregoing summary of distribution that the San Jose scale has now gained a foothold in no less than fourteen States east of the Rocky Mountains, and is known to have occurred in as many as twelve nurseries, from several of which it has been sent out broadcast for upward of seven years. The constant portage of nursery stock all through the Eastern States, on which there is not now, and never has been, the slightest restriction, has afforded most favorable opportunities for the spread of this insect. It is far from probable, therefore, that all the points at which it has become established have been located. In many instances it will doubtless be found to have gained access to the premises of persons who are indifferent and who will not take the trouble to examine their stock.

It will be seen also that while in the Eastern States at least active effort has been made in most instances to effect extermination, yet in

only two of these States has the scale probably been stamped out; and even in these States this is by no means certain. In a few instances little, if any, effort has been made to remedy the evil; as for instance, in Massachusetts, about Boston, and in some of the nurseries on Long Island. In most cases, however, where the scale has been located, prompt steps have been taken to effect extermination or such action has been faithfully promised, and in a number of important instances this has been followed up by a personal examination by agents of the Department of Agriculture or station entomologists, and the work of extermination found to have been as thorough as possible and seemingly effective. Many other points, however, have not been thus looked after, and we can only rely on the original promise of the owners to do their utmost to effect extermination.

The cases of the infested nurseries are of the greatest importance. Where, as in Maryland, the infestation was never very serious, the extermination seems to have been successful. On Long Island reasonable safety is assured in only one case, and this holds true also of Georgia. The Florida nurseries seem, on the authority of Professor Rolfs, to be in a satisfactory condition. The most important, however, are the New Jersey nurseries. These have been thoroughly overhauled, much of the infested stock having been uprooted and burned and the rest subjected to the most careful treatment, notably in the case of the nurseries near Burlington. On the authority of Professor Smith, these nurseries, particularly the one near Burlington, are now as safe places to buy stock as any in the East.

Nevertheless, the scale still exists in nurseries or in orchards in nearly all the States in which it has been located, and there is little or no question but that its dissemination is constantly going on.

Wherever the scale has become so thoroughly established as it is in New Jersey, Maryland, and on Long Island, it is doubtful whether it will ever be completely stamped out. The wide range of its food plants, and the ease with which it is carried by birds and insects, makes it always possible that it has gained a foothold in unsuspected places from which it will regain access to orchards and nurseries supposedly safely rid of it.

It is, therefore, practically impossible to say of any nursery or orchard that the scale is completely exterminated until a number of years have elapsed. The scale, when occurring singly or scantily, is discovered with great difficulty, and its absence can be determined only by a microscopic examination of every portion of the plant. It will hardly be noticed by the average fruit grower until it becomes very abundant; so much so, in fact, as to practically incrust the bark.

The foregoing considerations led us sometime ago to express the belief that there is scarcely any hope of ultimate extermination in the East, and that in the future we should have regularly to deal with the San Jose scale as we do with other well established insect enemies of

fruits. The probable impossibility of ultimate extermination has since been accepted by Professor Smith and others, who have been most interested in this scale and most familiar with it, and best able to judge the possibilities in this direction.

Careful experimentation with remedies, conducted by the division, however, has shown the complete feasibility of destroying the scale on infested trees. It is, therefore, simply a matter of careful work, accompanied, it is true, with some little expense, to put an orchard in fairly good condition; and even if complete extermination is not gained, the repetition of such treatment every few years will maintain a condition of vigor and fruitfulness which will probably warrant the outlay. The slowness with which the insect spreads when limited to its own efforts or to natural carriers, such as birds and insects, makes it highly desirable for all persons to use the greatest precautions to prevent its introduction into their orchards. It emphasizes, also, the importance of taking prompt and strenuous measures to stamp it out the moment it is found. If we may not, therefore, look forward to eliminating the San Jose scale from the list of Eastern fruit pests, we may at least hope to check its further spread and effect its extermination in every case where it has been recently introduced.

RELATION OF CLIMATE TO SPREAD.

The very extensive studies of the distribution of animal life in this country, and incidentally of plant life, conducted by Dr. C. Hart Merriam, have defined with approximate accuracy a number of well-marked climatic districts or life zones within which particular animals or plants thrive and outside of which they fail to establish themselves. The life zones thus limited have a special value in indicating the possible spread of many injurious insects, and we have suggested that they may prove to be particularly significant in the case of the San Jose scale. These life zones are: The tropical, occupying small areas in Florida and southern Texas; the lower and upper austral, covering the bulk of the United States; and the transition zone, coming between the last and the boreal zone of Canada and northward. These zones will be better understood by reference to the accompanying map (fig. 1), on which also the known distribution of the San Jose scale has been plotted.[1]

In the instance of the San Jose scale, it is at least suggestive of important possibilities, that although affected nursery stock has for six or seven years back been sent to all the fruit-growing regions of the Eastern States, according to our present information the scale has established itself only in regions contained within or near the so-called austral life zones. Mapping the points of establishment, it is very inter-

[1] A few infested localities, referred to in the text, discovered subsequently to the preparation of the map are not indicated.

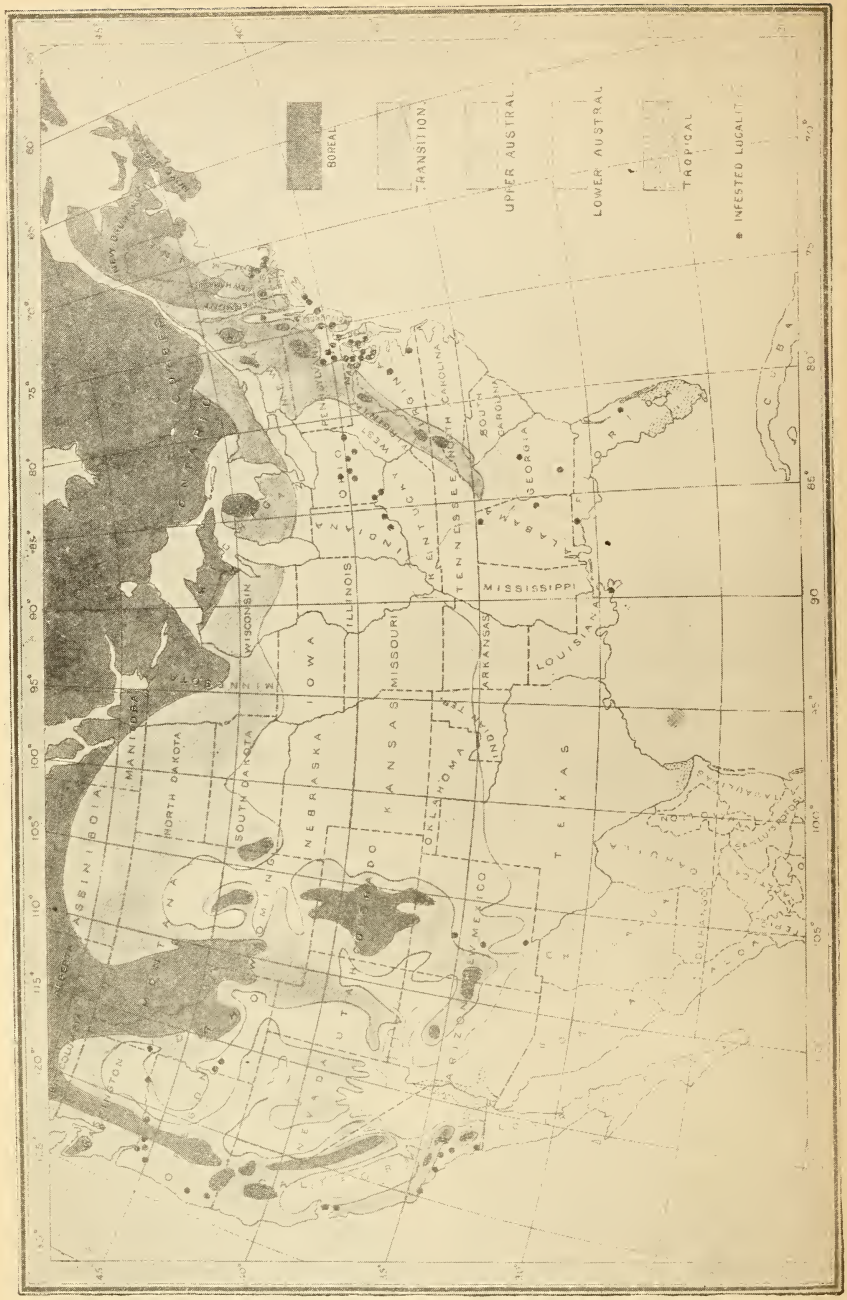

FIG. 1.—Map showing life zones of the United States and infested localities up to 1896.

esting to see how accurately this distribution has been followed. Professor Smith in 1894 called attention to the fact that the spread of the insect in New Jersey seemed to be limited on the north by the so-called "red shale" line, extending, approximately, from Perth Amboy on the east to Trenton on the west. If this limitation had been absolute it would have been curious and unusual, since the transition enters New Jersey only at the northwestern corner. Professor Smith, however, writes us under date of December 29, 1895, that the scale has been found at Washington, Warren County, north of the State line, and at the borders of the transition belt. The more northern occurrence of the scale in Columbia County, N. Y., is similarly significant, since the upper austral zone extends up the Hudson River. The occurrences at Lewisburg, Bristol, and Atglen, Pa., are all within the extension of the upper austral into the southeastern one-fifth of Pennsylvania. The two West Virginia occurrences are both in the upper austral strip in the western portion of the State. The three Idaho occurrences are all in the narrow upper Sonoran or upper austral band along the Snake River, with the exception of the one at Lewiston, which is the only locality in the panhandle of Idaho where the Sonoran dips in from the west. The occurrence at Amherst, Mass., may be explained by a hitherto not thoroughly realized extension of the upper austral up the Connecticut Valley, similar to the extension up the Hudson, and which the distribution of certain other insects seems to justify.[1] Those about Boston are probably to be explained by a more or less definite coast law which finds its extreme on the Pacific Slope, and which causes considerable overlapping of northern and southern forms. Should future observations support the apparent significance of the occurrences so far known, the scale will not establish itself to any serious extent in transition regions. This fact will relieve the fruit growers of much of New England; those inhabiting the greater portion of Pennsylvania, except in the southeastern one-fifth and a western strip; those in New York, except for the strip up the Hudson River and the loop which comes in from the northwest and includes the counties bordering Lake Ontario on the south, as well as those inhabiting the northern portion of the lower peninsula of Michigan (except for a strip along the east border of Lake Michigan) and all of northern Wisconsin, from any fear of this insect. Such a condition of affairs would seem almost too good to be true, but its possibility is suggested by what we know up to the present time. Against its probability may be urged the fact that, in general, scale insects belong to the group of potential cosmopolites, and that they are seldom restricted by geographical limitations which hold with other insects.

[1] This extension has recently been accepted by Dr. Merriam.

HABITS AND LIFE HISTORY.

NATURE OF THE DAMAGE.

The San Jose scale, as already stated, occurs on all parts of the plant, limbs, leaves, and fruit. As the plant becomes badly infested the scales lie very close together on the limbs, frequently overlapping, sometimes with several young ones clustering over the surface of an old mature scale. The general appearance which they present is of a grayish, very slightly roughened, scurfy deposit. The natural rich reddish color of the young limbs of peach, pear, and apple is quite obscured

FIG. 2.—Appearance of scale on bark: *a*, infested twig, natural size; *b*, bark as it appears under hand lens showing scales in various stages of development and young larvæ. (Original.)

when these trees are thickly infested, and they have then every appearance of being coated with ashes. When the scales are crushed by scraping, a yellowish, oily liquid will appear, resulting from the mashing of the soft yellow insects beneath the scales. Examined under a hand lens during the summer numbers of the little orange-colored larvæ will be seen running about, and the snowy white young scales will be interspersed with old brown or blackened mature scales. The appearance presented at this time under the lens is shown in the frontispiece and still more satisfactorily in the accompanying figure (fig. 2).

Very frequently the scale has a marked tendency to infest the extremities of the branches and twigs. This is particularly noticeable with pear. As usually found on peach, the scale is massed often more densely on the older growth, and works out more slowly toward the new wood.

The leaves are much less apt to bear scales, but in severe cases the upper surface particularly becomes infested, the scales frequently ranging in two or more quite regular rows on either side of the midrib. The male scales are more numerous on the leaves than the females. The infested leaves turn purplish brown.

The San Jose scale was formerly supposed to differ from all others in the peculiar reddening effect which it produces upon the skin of the fruit and of tender twigs. This, however, sometimes occurs with other scales, but is a particularly characteristic feature of this insect, and renders it easy to distinguish. The encircling band of reddish discoloration around the margin of each female scale is very noticeable on fruit, especially pears. This appearance, however, sometimes so closely resembles the small spots on fruit produced by a common fungus, *Entomosporium maculatum* Lev., as to require close examination with a lens to distinguish it. Fruit severely attacked becomes distorted, rough, and pitted, frequently cracking, and may eventually fall prematurely or at least become unmarketable.

The cambium layer of young twigs where the scales are massed together is usually stained deep red or purplish, and when the scale is only scatteringly present the distinctive purplish ring surrounding each is almost as noticeable on young twigs as on fruit, and is of the greatest service in facilitating the inspection of trees which have been subject to possible contagion. The almost microscopic young scale might easily elude the most careful search, but the striking circling ring makes them comparatively conspicuous objects without the aid of a glass.

If the tree survives the attack the infested wood eventually becomes knotty and irregular, partly from the sapping of the juices by the insect and also without doubt largely from the poisoning of the sap of the cambium layer by the punctures of the insect, as indicated by the discoloration. Young peach trees will ordinarily survive the scale only two or three years. Pears are sometimes killed outright, but generally maintain a feeble, sickly existence, making little or no growth for a somewhat longer period.

FOOD PLANTS.

Practically all deciduous fruit trees are subject to the attacks of this insect, including also various small fruits, such as the currant, gooseberry, etc. It has also been found on a great many shade trees and ornamental shrubs. The pear, peach, plum, apple, and cherry are almost equally liable to injury. The quince is apparently more rarely troubled. Notwithstanding its wide range of food plants, certain varieties of pear, strangely enough, seem to be almost never attacked,

if not entirely exempt. This holds, also, to a less extent with the different varieties of other fruits. Professor Smith says of plums that apparently Japanese varieties are favorites, while those of American and European origin suffer much less. The notable exceptions are, however, found in the case of pears. This is strikingly exhibited with the Leconte and Kieffer varieties, which are almost exempt.[1] A notable instance of the latter is the case of a tree which bore both Lawson and Kieffer grafts. The Lawson branch, leaves and fruit, was entirely covered, while the Kieffer portion was entirely free from the scale. No other variety of pear has been found equal to the Leconte and Kieffer in immunity. The following list of food plants is substantially as compiled by Dr. Lintner:

Tiliaceæ:
- Linden.

Celastraceæ:
- Euonymus.

Rosaceæ:
- Almond.
- Peach.
- Apricot.
- Plum.
- Cherry.
- Spiræa.
- Raspberry.
- Rose.
- Hawthorn.
- Cotoneaster.
- Pear.
- Apple.
- Quince.
- Flowering quince.

Saxifragaceæ:
- Gooseberry.
- Currant.
- Flowering currant.

Ebenaceæ:
- Persimmon.

Leguminosæ:
- Acacia.

Urticaceæ:
- Elm.
- Osage orange.

Juglandaceæ:
- English walnut.
- Pecan.

Betulaceæ:
- Alder?

Salicaceæ:
- Weeping willow.
- Laurel-leaved willow (from Asia).

LIFE HISTORY.

In common with all the armored scales, the life round of this insect, with the exception of a few hours of active larval existence and an equally brief winged existence in the case of the mature male, is passed under the protection of a waxy scale. This scale covering conceals the real insect beneath and prevents any easy observation or study of its life history. The San Jose scale has been under most careful observation by Mr. Pergande on potted plants in the insectary, and its history, which has hitherto been very imperfectly worked out, has been thoroughly and carefully elaborated.

The winter is passed by the nearly full-grown insects under the protection of the scale. Early in April in this latitude the hibernating males emerge, and by the middle of May the overwintered females mature and begin to give birth to a new generation, continuing to produce young for a period of upward of six weeks, when they reach the limit of production of young and perish.

[1] Mr. Charles Parry has recently observed cases in which both Kieffer and Leconte pears have been badly damaged.

The adult female gives birth immediately to living young, differing in this respect from most other scale insects. Ordinarily eggs are deposited beneath the scale, which in the course of a longer or shorter time hatch, and the young larvæ make their escape and migrate to different parts of the plant. In the case of some scale insects the female fills its scale with eggs in the fall and perishes, the eggs wintering over and hatching the following spring. In others the insect hibernates in the nearly mature condition, as does the San Jose scale, and deposits eggs in the spring or early summer. The viviparous habit, or the giving birth to the living young, possessed by the San Jose scale, finds a parallel in many other insects and frequently in plant-lice. In the case of the San Jose scale the eggs are fairly well formed.

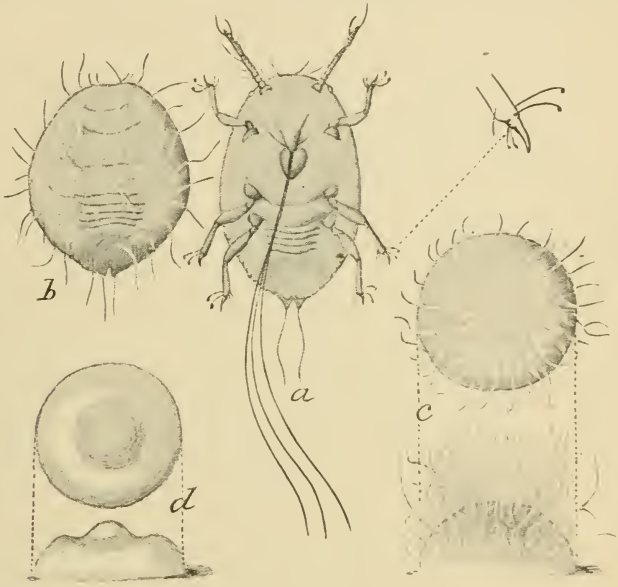

FIG. 3.—Young larva and developing scale: *a*, ventral view of larva, showing sucking beak with setæ separated, with enlarged tarsal claw at right; *b*, dorsal view of same, somewhat contracted with the first waxy filaments appearing; *c*, dorsal and lateral views of same, still more contracted, illustrating further development of wax secretion; *d*, later stage of same, dorsal and lateral views showing matting of wax secretions and first form of young scale—all greatly enlarged. (Original.)

a few at a time, within the body of the mother. What takes the place of the eggshell consists of a very delicate and thin membrane—the amnion—which incloses the developing larvæ and which at the moment of birth is cast off, and remains attached to or partly within the oviduct. The amnion is probably pushed out by the next larva in turn. The difference between this mode of birth and the ordinary method through the medium of true eggs is simply that what corresponds with the egg is retained by the female until the larva is developed, instead of development of the larva progressing after the egg leaves the parent.

The emergence of the young from the female over a period of six weeks leads to a very confusing intermingling of generations and renders it

difficult to make observations on the life history except by isolating and watching individuals. By means of such isolation of individuals, however, we have been able to most carefully trace the different generations. The course of the development of a single generation follows:

After being expelled the larva remains motionless for a little while, with antennæ and legs folded beneath the body. It soon hardens enough to run about, and forcing its way out from beneath the protecting scale of the mother, scurries over the plant to find a suitable place to settle.

The newly born larva (fig. 3*a*) is an almost microscopic creature of pale orange yellow color, with long oval body, and with the customary six legs and two feelers. The long thread-like proboscis with which the juices of the plant are sucked up is doubled on itself and lies in an invagination of the body wall, the tip only projecting.

After crawling about for a few hours, the young larva settles down and slowly works its long bristle-like sucking beak through the bark, folds its antennæ and legs beneath its body and contracts to a nearly circular form. The development of the scale begins even before the larva becomes fixed. The secretion starts in the form of very minute white fibrous waxy filaments, which spring from all parts of the body and rapidly become more numerous and dense (fig. 3*b*, *c*). At first the orange color of the larva shows through the thickening downy white envelope, but within two days the insect becomes entirely concealed by the white or pale grayish yellow shell or scale, which now has a prominent central nipple (fig. 3*d*), the younger ones often possessing instead a central tuft. The scale is formed by the slow matting and melting together of the filaments of wax. During the first day the scale appears like a very microscopic downy hemisphere. The matting of the secretion continues until the appearance of down and individual filaments is entirely lost and the surface becomes smooth. In the early history of the scale it maintains its pale whitish or grayish yellow color, turning gradually darker gray, the central nipple remaining lighter colored usually throughout development.

The male and female scales are exactly similar in size, color, and shape until after the first molt, which occurs twelve days after the emergence of the larva. With this molt, however, the insects beneath the scale lose all resemblance to each other. The males (fig. 4*a*) are rather larger than the females, and have large purple eyes, while the females have lost their eyes entirely. The legs and antennæ have disappeared in both sexes. The males are elongate and pyriform, while the females are almost circular, amounting practically to a flattened sac with indistinct segmentation, and without organs, except a long sucking bristle springing from near the center beneath. The color of both sexes is light lemon yellow. The scales at this time have a decidedly grayish tint, overcast somewhat with yellow.

Eighteen days from birth the males change to the first pupal condition (pro-pupa), (fig. 4*b*) and the male scales assume an elongate oval,

sometimes slightly curved shape, characteristic of the sex, the exuvia or cast larval skin showing near the anterior end.

The male pro-pupæ are very pale yellow, with the legs and antennæ (which have reappeared) together with the two or three terminal segments colorless. The eyes are dark purple and placed close together. The antennæ are stout and bent closely along the edge of the body as far as the first pair of legs, where they curve slightly inward. Prominent wing pads extending along the side of the body. The terminal segment bears two short spines.

The female undergoes a second molt about twenty days from the larva. At each molt the old skin splits around the edge of the body the upper half adhering to the covering scale and the lower forming a sort of ventral scale next to the bark. This form of molting is common to scales of this kind.

The covering scales at this stage are of a more purplish gray, the portion covering the exuviæ inclining to yellowish. The male scales are more yellowish than the female. The effect of the sucking of the insects is now quite apparent on the young growth, causing the bark

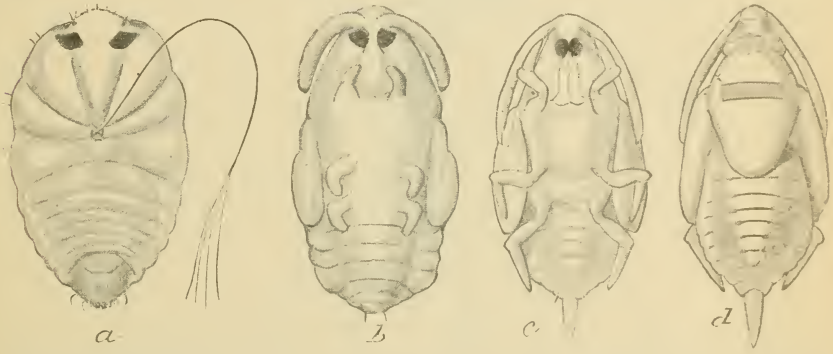

FIG. 4.—Development of male insect: *a*, ventral view of larva after first molt; *b*, same, after second molt (pro-pupa stage); *c* and *d*, true pupa, ventral and dorsal views. All greatly enlarged. (Original.)

to assume a purplish hue for some distance around the central portion, contrasting strongly with the natural reddish green of the uninjured bark. With the second molt the females do not change materially from their former appearance, retaining the pale yellow color with a number of transparent spots around the edge of the body. The sucking bristles are extremely long, two or three times the length of the body of the insect. The only distinctive features are in the last segment and are noted in the technical description.

About twenty days after birth the male insect transforms to the true pupa. With the first molt the shed larval skin is retained beneath the scale as in the case of the female; with the later moltings the shed skins are pushed out from beneath the scale. The scale, after the second molt, presents on the inside two longitudinal ridges running from one end to the other, touching the sides of the pupa, and which apparently enable the insect to move backward or forward and assist the imago in pushing itself out.

The true pupa (fig. 4*c*, *d*) is pale yellow, sometimes purplish, darkest about the base of the abdomen. The head, antennæ, legs, wing pads, and style are well formed, but almost colorless. The antennæ reach as far back as the second pair of legs and are not curved under, as formerly, but lie close to the side of the body with the ends free. The first pair of legs are held forward, reaching slightly beyond the eyes, the middle femora projecting somewhat beyond the margin of the abdomen. The hind legs are inclined backward and reach to the end of the body. The style is rounded at tip, conical, and about as long as the posterior tibiæ.

From four to six days later, or from twenty-four to twenty-six days from birth, the males mature and back out from the rear end of their scales, having previously, for a day or two, remained practically developed but resting under the scale. They seem to issue chiefly by night or in the evening.

The mature male (fig. 5) appears as a delicate two-winged fly-like insect with long feelers and a single anal style projecting from the end

FIG. 5.—Adult male—greatly enlarged. (Original.)

of the body; orange in color, with a faintly dusky shade on the prothorax. The head is darker than the rest of the body, the eyes are dark purple, and the antennæ, legs, and style are smoky. The wings are iridescent with yellow and green, very faintly clouded.

Thirty days from birth the females are full grown and the embryonic young may be seen within their bodies, each inclosed in a delicate membrane. At from thirty-three to forty days the larvæ again begin to make their appearance.

The adult female, prior to the development of the young, measures 1 millimeter in length and a little less in breadth, and is pale yellow with transparent spots near the margin of the body (fig. 6).

The length of a generation is determined by the female, and, as shown by the above record, covers a period of from thirty-three to forty days. Successive generations were followed carefully throughout the summer, and it was found that at Washington four full generations

are regularly developed, with the possibility of a partial fifth generation. On a number of potted trees a single overwintered female was left to each tree. After the full progeny of this individual had gone out over the tree, all were removed again, except one of the oldest and

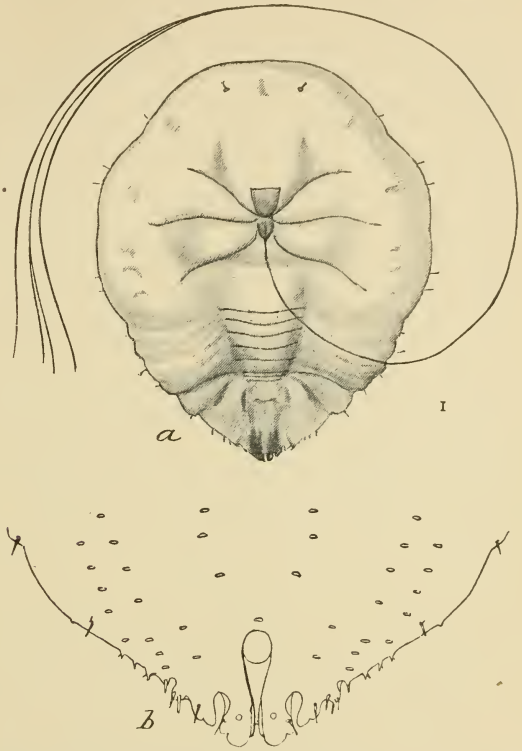

FIG. 6.—Adult female, before development of eggs: *a*, ventral view, showing very long sucking setæ; *b*, anal plate, showing characteristic ornamentation of edge—greatly enlarged. (Original.)

fertilized females. This method was continued for each generation throughout the breeding season. Some interesting records, tabulated below, were thus obtained, which indicate the fecundity of the females as well as the number of generations.

Number of tree.	Males.	Females.	Total.	Number of tree.	Males.	Females.	Total.
	Progeny of overwintered females.				*Progeny of third generation.*		
1	72	34	106	1	110	307	417
2	77	43	120	2	122	464	586
3	138	60	198	3	190	284	474
4	18	22	40	4	187	400	587
5	98	60	158	5	174	280	454
6	33	25	58	6	107	274	354
7	13	.....	13		*Progeny of fourth generation.*		
	Progeny of second generation.			1	242	319	561
1	350	235	585	2	112	230	342
2	276	226	502	3	92	170	262
3	325	92	417	4	210	344	554
4	192	120	312	5	242	343	585
5	415	151	556	6	156	293	449
6	206	124	330				

Perhaps the most notable feature of the foregoing records is the result obtained from the overwintered females. It will be seen that the males greatly predominate in this generation, and that the numbers of both sexes are insignificant compared with the progeny of the later generations. The males still predominate in the second generation, but in the third and fourth generations the females considerably outnumber the males, in one instance the females from a single mother reaching the astonishing number of 464, which, with 122 males from the same parent, makes the progeny of this female 586 insects. Taking 200 females as an average of the different generations for the year, the product of a single individual from spring to fall amounts to 1,608,040,200 females. In one instance we have over 415 males from a single female, and while the number of males would average somewhat less than the females, taking the summer through, yet, having underestimated the females, the males may be estimated at the same number, giving a total of 3,216,080,400 descendants from a single insect in a single season. It is not to be expected, of course, that all the individuals from a scale survive and perform their function in life, but under favorable conditions, or in the case of a tree newly infested or not heavily incrusted, the vast majority undoubtedly go through their existence without accident. Neither the rapidity with which trees become infested nor the fatal effect which so early follows the appearance of this scale insect is therefore to be wondered at.

Owing to the long period during which the female is continuously producing young, the different generations or broods in the course of the summer are not distinctly marked and merge insensibly into each other—so much so that at almost any time there will be found young larvæ running about over the trees and scales in all stages of development. Still, at certain times the young will be noticeably more abundant, indicating periods when the majority of each generation are producing young. In this latitude the first young appear, as noted, by the middle of May, at Amherst, Mass., they were first noticed June 12, and in Arizona they are recorded as appearing in March. The larvæ are continuously present on the trees until further hatching is prevented by severe frosts. In 1894, as we have already shown on page 289 of Volume VII of Insect Life, the first frosts at Washington occurred in the latter part of October and the hatching of the young ceased before the 1st of November. October 24, 1894, however, Mr. Howard saw recently settled larvæ, not more than 5 days old, at Lewisburg, Pa. In 1895 the October frosts were insignificant, and in this neighborhood no severe frost occurred until about the 1st of December. The result was that young larvæ were found at Washington until late in November, while on twigs received from Chestertown, Md., November 13 and November 27, the young were more or less abundant. The cold spell of the last week in November and the first week in December put a stop to development here. This same cold spell was of very wide extent. As

far to the southwest as San Antonio, Tex., the thermometer dropped to 31° on December 3. A similar, or even lower, temperature was noted at New Orleans, yet, on December 16, Mr. Howard found newly hatched young, less than 24 hours old, upon a plum tree at Audubon Park, New Orleans.

In autumn, or when further development is stopped by cold weather, hibernation is begun by scales in all stages of development, from the white, minute, down-covered recently hatched young to the mature and full-grown females and males. Unquestionably many young perish during the winter, and normally in spring quite a percentage of the smaller or half-grown scales will be found to have perished. It is very probable that many females have union with the males in the fall, but the majority of them are unquestionably immature, and are fertilized in this latitude early in April by overwintered males which, as we have noted, appear nearly a month before the first young of the spring brood.

The actual rate of the production of young at different periods of the life of the adult female has not been determined with accuracy. As the average reproducing period of the adult female is six weeks, and as the average number of young from each female is about 400, there must be born from 9 to 10 young every twenty-four hours. The great labor of watching an individual female and removing every twenty-four hours the young she has given birth to during that period has not been entered upon. Sufficient observations have been made, however, to indicate that the main period of reproductive activity is the second or third week after the female has reached maturity. At first the young are born with less frequency, and there is a corresponding reduction in reproductive activity toward the end of the life of the individual. The young are born indifferently by day or by night, perhaps more during the day than during the night. In the morning, however, examination of the trees under observation always shows many migrating young which must have been born during the night, while observations at nightfall show always as many, and frequently more, which have been born during the day.

The gradual production of the young by the female has an important bearing on the question of remedies, and the old washes, which aimed at the destruction of the young as soon as they emerge from the females, are rendered almost valueless because, to make them effective, it is necessary to repeat them many times during a period of six weeks. Within two or three days after hatching the young larvæ will have formed a scale which will be impervious to these weaker washes.

The larva does not ordinarily travel far from the parent insect, and usually rests within a few inches of the old scale or at the first available point. They will not, so far as observed, travel very far from the base of the tree, and in the potted trees none were observed to go more than 2 inches from the base of the trunk.

DESCRIPTIONS OF SCALE AND INSECT.

Scale of female.—The scale of the female is circular, very slightly raised centrally, and varies in diameter from 1 to 2^{mm}, averaging about 1.4^{mm}. The exuviæ is central or nearly so. The large, well-developed scales are gray, excepting the central part covering the exuviæ, which varies from pale to reddish yellow, although in some cases dark colored. The scale is usually smooth exteriorly or sometimes slightly annulated, and the limits of the larval scale are always plainly marked. The natural color of the scale is frequently obscured by the presence of the sooty fungus (*Fumago salicina*).

Scale of male.—The mature male scale is oblong-oval, nearly twice as long as wide, and averaging in length about half the diameter of the female scale. The position of the larval scale is marked by a nipple-like prominence located between the center and the anterior margin of the scale. The scale of the male is usually darker than of the female, sometimes black, but often gray, the larval scale covering the exuviæ very frequently light yellow as with the female. Not uncommonly the circular scale, formed prior to the first molt, is black, while the later additions, giving it its oblong shape, are gray.

Egg.—The egg is never (or rarely) extruded as such by the female, and as it exists within the body of the mother is a mere amniotic membrane, and the forming embryo showing through gives it a yellowish-white color. The embryo with the envelope measures about 0.2^{mm} long by 0.1^{mm} wide.

Newly hatched larva.—The young larvæ of both sexes are alike, and are pale orange in color, with long oval bodies. They measure in length about 0.24^{mm} by 0.1^{mm} in width. The sucking bristles are normally doubled on themselves, but when unfolded are nearly three times the length of the body. The antennæ are apparently five-jointed, the last two joints being much longer than the others, slender, subequal in length, and both finely and distinctly annulated. The last joint bears a small nipple-like projection near the tip. The head is somewhat concave in front, and the eyes are nearly transparent and slightly purplish. The terminal segment of the abdomen foreshadows in structure the plates and spines of the adult female. The large central plates each terminate in a long hair. The tarsus is represented by apparently a single, strong, slightly curved claw. The tip of the tibia bears exteriorly two rather long capitate hairs, and two similar hairs project also from the inner extremity. Other details of structure are shown in the illustration.

Larva of the second stage.—After the first molt the difference in the sexes becomes apparent, although the covering scales are still identical.

The female insects are somewhat smaller than the males at this stage. The eyes, legs, and antennæ in this sex have entirely disappeared. The form is almost circular, flattened. The color is yellow with irregular transparent spots appearing in different parts of the body.

The males are somewhat larger than the females, elongate, pyriform. The eyes are prominent, purple in color. The legs and antennæ, as with the females, are wanting. The general color of the body is yellow, with the irregular transparent spots noted in the case of the female. The greatest diameter in both sexes is less than one-half a millimeter, and in the characteristics of the terminal segment both agree, practically, with the adult female.

Male pro-pupa.—With the second molt the male assumes a form foreshadowing the true pupa, which may be called the pro-pupa.[1] The form is elongate oval; length, 0.5mm. The color is very pale yellow, with the antennæ, limbs, and wingpads, and two or three terminal segments of the abdomen, colorless. The legs and antennæ, as noted, have reappeared, and also prominent pads foreshadowing the wings of adult. The eyes are dark purple and placed close together. The antennæ are very stout, and curved closely around the edge of the body as far as the anterior legs, where they bend inward. The wingpads are stout and almost entirely cover the abdomen. The terminal segment is still broad and flattened and bears two short spines, but the other characters have disappeared.

True pupa of male.—The true pupa resembles the previous stage, except that the members are longer and slenderer, and the prominent anal style has appeared. The pupa is pale yellow and purplish in color, darkest about the base of the abdomen, the head, antennæ, legs, wing sheaths, and style being almost colorless and transparent. The eye spots are dark purple. The antennæ extend nearly to the middle femora, and are not curved under the body as formerly, but are applied close to the sides with the apex free. The anterior legs are held forward, reaching slightly beyond the eyes. The middle femora rest transversely to the body, projecting somewhat beyond the margin of the abdomen, while their tibiæ form with them a right angle and reach nearly to the apex of the hind femora. The latter incline posteriorly, while the hind tibiæ are applied close to the sides of the body, except toward the tip, and reach nearly to the base of the style. The style is rather stout, conical, obtusely pointed at tip, and about as long as posterior tibiæ. Length, 0.8mm, including style, which measures about 0.15mm.

Mature male.—The general color is orange with a faint duskiness on the prothorax. The head is somewhat darker than the rest of the body. The eyes are dark purple, almost black. The antennæ are yellow, somewhat obscure or smoky. The legs and style are dusky, the latter paler than the former. The thoracic shield is regularly ovoid, compressed anteriorly, dusky in color, with margin brown, more distinctly so anteriorly; transverse band narrow, brown. Antennæ 10-jointed, two basal

[1]The existence of a pro-pupa or a first pupal stage in the Coccidæ analogous to the first pupal stage of higher Hemiptera has also been affirmed by Dr. Fr. Loew. (*Wiener Entom. Zeit.*, Jan., 1884, p. 13.)

joints shortest, second nearly globular, inserted in the first; joints 4 and 5 subequal, longer than any of the others; joint 6 next in length, and joints 3, 7, and 9 shorter and subequal; joint 10 still shorter, conical. Antennæ somewhat hairy and nearly as long as the body of the insect. Wings, faintly dusky, iridescent with yellow and green. Length of body about 0.6mm; style, 0.25mm.

Female, third stage.—After the second molt the females still appear pale yellow as before with various larger and smaller transparent spots around the border of the body. The form is nearly circular with greatest diameter averaging 0.56mm. The sucking bristles are very prominent and long, three times the length of the insect. The last segment in this stage has practically the characters of the mature female, as follows: There are two pairs of lobes, the terminal ones largest and nearly three times as broad as the other lobes. Terminal lobes are rounded at the apex and are distinctly notched near the middle of the external edge. The second pair of lobes is smaller and narrower and is also notched externally. Between the first and second lobe on either side is a small spine and two or three such spines are just back of the second lobe, while back of these are three stout teeth, curving anteriorly. A still smaller blunt tooth sometimes occurs near the middle of the lateral margin. The segmentation of the body at this stage is quite distinct.

Mature female.—After reaching maturity the embryonic young are at first not visible, but later the body becomes filled with them. The mature female measures 0.8mm wide by about 1mm long. [1]

The following description of this stage is reproduced from Comstock:

The body of the female is yellowish and almost circular in outline; the segmentation is distinct, though not conspicuous. The last segment presents the following characters:

There are only two pairs of lobes visible; the first pair converge at tip, are notched about midway their length on the lateral margin, and often bear a slight notch on the mesal margin near the tip. The second pair are notched once on the lateral margin.

The margin of the ventral surface of the segment is deeply incised twice on each side of the meson; once between the bases of the first and second lobes and again laterad of the second lobe. On each side of each of these incisions is a club-shaped thickening of the body wall.

There are two inconspicuous simple plates between the median lobes, and on each side similar plates extending caudad of the first incision, three small plates serrate on their lateral margin caudad of the second incision, and the club-shaped thickenings of the body wall bounding it, and three wide prolongations of the margin between the third and fourth spines. These prolongations are usually fringed on their distal margins. There are also, in some, irregular prolongations of the margin between the fourth spine and the penultimate segment.

The first and second spines are situated laterad of the first and second lobes, respectively; the third spine laterad of second incision; and the fourth spine about one-half the distance from the first lobe to the penultimate segment.

[1] Rept U. S. Dept. Agric., 1880, p. 304.

MEANS OF DISTRIBUTION.

From an economic standpoint, the important considerations in the means of spread of this insect are those which affect its wide distribution from one part of the country to another. The transportation by nursery stock or scions or budding and grafting material, as indicated in the foregoing account of this insect, is unquestionably the usual and principal means of carrying the insect to a distance. The importance of this means of distributing various insects has only been fully realized in this country in the last few years, but the present instance and some other notable ones of like nature have emphasized the great danger incurred not only in the indiscriminate introduction of plants from foreign sources, but also in the carriage of plants from one part of the country to another without competent inspection. The San Jose scale is also frequently carried about on fruit, as the young very commonly crawls out upon the fruit, particularly with the pear, and is thus shipped to remote points. It may be frequently thrown out on parings and the young larva may gain access in this way to trees. This method of transportation was strikingly illustrated at the meeting of the Association of Economic Entomologists held in Brooklyn, in 1894, when Prof. J. B. Smith exhibited a number of California pears purchased from the nearest fruit stand, all of which were badly infested with the scale, showing many full-grown females and in some cases young larvæ crawling about. Such fruit is sold on all trains and in practically all large towns in the United States. Prof. J. W. Toumey states (Bulletin 14, Arizona Experiment Station, p. 36) that he has purchased California pears and apples in the fruit stalls of Phœnix and Tucson infested with both female and male scales, and Professor Smith reports a like experience in the markets of Philadelphia, Newark, New York, and Brooklyn. The danger of infestation from parings and rejected fruit will therefore be easily understood.

The spread of the insect from orchard to orchard and from tree to tree must also be brought about through the agency of means other than those under the control of the insect itself. The female is wingless, and after once becoming fixed, can not move. The young lice, as before stated, are active, crawl rapidly, and may reach other trees, but this is rare unless the limbs interlace, since we have shown by breeding-cage experiments that the larvæ normally crawl but a few inches. Such spread, however, is comparatively insignificant except in the case of nursery stock, which is grown close together. It is possible that strong winds may carry the young bodily from one tree to another, or, they may be floated on water to distant points, particularly in irrigated districts, but the principal method of the spread of these young lice is by means of other insects, and by birds. The active young lice soon crawl upon any small winged

insect, particularly if the latter be of a dark color, and may thus be carried considerable distances. They are frequently found crawling upon ants which are great travelers. It is extremely probable that they also crawl upon the feet of birds, and may be transported by these carriers for many miles.

Some interesting observations have been made by Mr. Schwarz upon the transporting of these scale larvæ by other insects. A little black lady bird, *Pentilia misella*, which was very active in devouring scale larvæ, was unfortunately equally efficient in transporting many of these young lice to other parts of the tree or to other trees; in fact, it was difficult to find a single beetle which did not carry on its back at least one larva of the San Jose scale, and sometimes three or four were found upon a single wing-cover of a beetle. The small black ant, *Monomorium minutum*, was particularly abundant upon pears, attracted by the juices emerging from cracks, and almost every one of these insects carried on its back one or more specimens of the young scale insects. Specimens of the little chrysomelid beetle, *Typophorus canellus*, were also found upon the trees. Both red and black specimens of this beetle occurred, and the interesting observation was made that while Aspidiotus larvæ crawled freely on the black individuals, no specimens were to be found upon the red ones. The same peculiarity was found to hold true with the ants. The red ant, *Formica schaufussi*, was abundant upon the pears, but no specimens were found bearing Aspidiotus larvæ, while, as just stated, the little black Monomorium was always found carrying them.

As illustrating this transportation of the scale by birds or insects the experience at Riverside, Md. (ante, p. 25), may be cited, and Professor Smith reports a similar instance in New Jersey, in letter of January 13, 1896.

In spite of the abundance of insects which may transport the larvæ the progress of the scale from infested trees to noninfested trees is slow, where trees are moderately widely separated, and usually an entire orchard will not become affected from a single original point for several years.

Occasionally the young scales may be locally transported by men or teams. An interesting case in point is given by Professor Rolfs. He states that some melons growing in an infested orchard were given by the owner to a friend, who took them away from the orchard in his wagon. A year later the scale developed on a tree under which the team had been hitched while the melons were unloaded. As this orchard was entirely free from the scale originally, it seems to be a reasonable inference that the young had crawled upon the wagon, harness, or melons, were conveyed a distance of three miles, and succeeded in gaining access to a tree which probably touched the wagon or team during the interval of unloading.

THE PARASITES AND NATURAL ENEMIES.

TRUE PARASITES.

Of true parasites, three have been reared from the San Jose scale in California and three in the East, two of the latter being the same as two of those occurring on the Pacific Slope. The most important parasite perhaps is *Aphelinus fuscipennis* How., a common and widespread enemy of armored scales. The general characteristics of *fuscipennis* are well shown in the accompanying figure of a closely allied species (fig. 7). This parasite has been reared in large numbers by Mr. Coquillett in California, where he found it to breed throughout the year, obtaining specimens as late as November 10. In the East several specimens of this insect have been reared by Professor Smith in New Jersey, and we have found scales at Riverside, Md., and Charlottesville, Va., pierced with holes which were probably made by this species. The two other Western parasites were reared by Mr. E. M. Ehrhorn in

FIG. 7.—*Aphelinus diaspidis* How.

Santa Clara County, Cal., and are *Aphelinus mytilaspidis* Le B. and *Aspidiotiphagus citrinus* Craw. The other Eastern parasites are *Aspidiotiphagus citrinus* Craw, recently reared from scales from W. E. Hudson, Orlando, Fla., and *Anaphes gracilis* How., which was reared originally from specimens collected at Riverside, Md., and later from affected twigs received from Charlottesville, Va. It is only fair to suggest that the latter species may not eventually prove to be a parasite of the San Jose scale, since overlooked specimens of the common oyster-shell bark-louse may have been present on the same twigs. The type of this species was obtained in 1880 from *Mytilaspis pomorum*, the common oyster-shell bark-louse of the apple.

Aphelinus fuscipennis is undoubtedly a very efficient aid in keeping the San Jose scale in check. Mr. Alexander Craw, in the report of the State Board of Horticulture of California for 1891, states that he found it doing such effective work in an orchard in the neighborhood of Los Angeles that complete extermination of the scale was confidently looked

for. It was afterwards learned, however, that the orchard became reinfested and also that the partial extermination of the scale in this instance was in a measure seemingly due to a fungous disease.

Mr. Koeble refers to the fact that in the case of infested trees on the island of Kauai the scales were nearly all punctured by a minute parasite which he thought might be this species.

PREDACEOUS INSECT ENEMIES.

Of predaceous insects, perhaps the most interesting is the little coccinellid *Pentilia misella*, which in both the larval and beetle state was found by Mr. Schwarz in great numbers at Charlottesville feeding upon

FIG. 8.—*Pentilia (Smilia) misella: a*, beetle; *b*, larva; *c*, pupa; *d*, blossom end of pear, showing scales with larvæ and pupæ of Pentilia feeding on them, and pupæ of Pentilia attached within the calyx—all greatly enlarged. (Original.)

the scale, and which also occurs in other Eastern localities. The present season we found its larvæ on twigs from Chestertown, Md., collected late in November. The beetles seem to prefer the full-grown female scales, and were frequently observed standing astride a scale, almost on end, pushing their heads under the margin of the protecting scale to get at the soft yellow insect beneath. The larvæ of the beetles seem to feed more abundantly on the young scales. Their mode of attacking the older scales was not observed. No eggs of this very useful coccinellid were found, but a favorite place of pupation was discovered to be within the calyx of the pears. This cavity is often literally filled with a mixture of young and old scale insects, and frequently contained full-grown Pentilia larvæ, their pupæ, and also freshly issued beetles. (See fig. 8.)

The fact that this beetle, which is essentially an Eastern species, so

readily and effectively took hold of this introduced scale, is very interesting, entomologically, and, as suggested at the time, would justify an effort to introduce it into southern California. Following up this idea, a considerable number of living and healthy specimens were sent, in May, 1894, to Prof. C. W. Woodworth, at Berkeley, Cal., who wrote that the insects were received in good condition, and that they had been placed upon a well infested tree at Oakland where they could be kept under observation. Since that time, in spite of repeated inquiries, we have been unable to get any information from Professor Woodworth as to the outcome of the experiment.

Our account of this useful beetle coming to the attention of Mr. J. E. McIntyre, of Lespe, Cal., he urged us to procure for him some living specimens. Having already sent material to Mr. Woodworth, we were not immediately able to get a supply of the insects for a sending, but at this juncture we received from Mr. G. W. Harney, of Marysville, Cal., some beetles for determination, which proved to be *Pentilia misella*. He reported that in the mountainous regions of Yuba County many apple trees had been very badly infested with *A. perniciosus*, and that hundreds of these little ladybirds were found preying on the scale. The occurrence of this ladybird in California as thus determined, and the fact that it there had the same useful habit, was a most interesting discovery. We immediately had Mr. McIntyre's request transferred to Mr. Harney for attention. It is more than likely that this little beetle is already widely distributed over the Pacific Slope, and it may prove to have a continental distribution instead of being restricted to the East, as originally supposed.

In California the common twice-stabbed ladybird *Chilocorus bivulnerus* is very common and active on trees infested with the San Jose scale, and is an important aid in keeping the scale in check. This species has been reported by Mr. N. W. Motheral, a year or two after having been introduced, to have multiplied in immense numbers and to have effected the extermination of the scale in orchards in Tulare County, Cal. (Insect Life, Vol. V, p. 53.) In the East, however, this ladybird, although common, does not seem to be attracted to this scale.

Various species of the ladybirds introduced, through the agency of Mr. Koebele, from Australia were colonized on trees infested with *Aspidiotus perniciosus*, and of these *Orcus chalybeus*, *O. australasiæ*, and *Scymnus lophanthæ* have since been found preying upon the San Jose scale. (Insect Life, Vol. V, pp. 128, 251; Vol. VI, p. 271.) The last-named species was one of the lot introduced by Mr. Koebele on his first Australian trip (1888–89), and was subsequently lost sight of. In 1892 Dr. F. E. Blaisdell described it (Entomological News, Vol. III, p. 51) as a new California species of Scymnus, naming it *S. lophanthæ* from the fact of his finding it preying on the San Jose scale which infested the limbs of *Acacia lophantha* near San Diego, Cal. The interesting facts thus shown are the establishment of the beetle in California and its very useful habit. (Insect Life, Vol. V, p. 127.)

We are informed also by Hon. Elwood Cooper, president of the State Board of Horticulture of California, that of the last importation by Mr. Koebele two species of Rhizobius (*R. ventralis* and *R. debilis*) have been found to feed on various scales in California, including the San Jose scale, but to what extent is not yet known. An undetermined native ladybird, Scymnus sp., has also been observed in California feeding upon the San Jose scale, and there can be no question that most of our common native ladybirds will acquire this habit, and also many of our common predaceous insects, notably the larvæ of lace-winged flies.

Great confidence is being expressed by fruit growers in California as to the efficacy of these predaceous insects, and there is a tendency more and more to give up spraying operations and leave the work of the protection of orchards solely to these natural agencies. In explanation of the great benefit experienced in California from natural enemies of scales, Mr. Cooper (letter of December 18, 1894), is of the opinion that this results from the fact that the climate of California is sufficiently mild to enable many of the predatory species to multiply uninterruptedly the year round. The twice-stabbed ladybird, he says, occurs on plants throughout December and January in great numbers in all stages.

Valuable as these natural enemies undoubtedly are, however, they will be efficient only at intervals and there will always be considerable periods when, for one cause or another, they will be less numerous, and the scales will then have a chance to multiply. In fact, after the scale has once become established and the balance between it and its natural enemies has been reached, we may expect with more or less regularity periods of abundance and scarcity of the scale insect. The possible usefulness of parasitic and predaceous insects should, therefore, at least in the East, not be allowed for a moment to interfere with active operations with remedies nor blind one to the importance of the San Jose scale and the extraordinary precautions which should always be taken to prevent its wider dissemination. We have nevertheless as an experiment arranged to introduce certain of the Australian ladybirds into affected Maryland orchards the coming spring.[1]

A FUNGOUS DISEASE.

Some years ago Mr. Coquillett transmitted to this office from California some specimens of the San Jose scale which had died from some unaccountable cause, supposedly from a fungous disease. He refers to this disease in Bulletin 26 of this Division, page 22, as follows: "A few weeks ago Mr. C. H. Richardson, of Pasadena, one of the county inspectors of fruit pests, showed me several pear trees in that locality which a year ago were very thickly infested with these scales, as was evidenced by the gnarled appearance of the branches as well as by the

[1] Since this paragraph was written we learn that the New Jersey State Board of Agriculture has passed a resolution calling upon the State legislature to appropriate the sum of $1,000 for the purpose of introducing ladybirds from California into affected New Jersey orchards. If the bill should pass, the attempt will be made in the spring of 1896.

dry scales still adhering to the trees. After a careful examination of these scales scarcely a live one could be found. Mr. Richardson assured me that the trees had not been treated with any kind of insecticide, and they certainly gave no evidence of such treatment. The dead scales showed no indications of having been destroyed by ladybirds nor yet by internal parasites. Wishing to ascertain if this singular mortality was general among these scales in other localities, I examined several infested pear trees in this city, but found that the fruit and new growth upon them were thickly infested with these scales, which were alive and to all appearances in a very thriving condition. It would appear, therefore, that this mortality among the San Jose scales was entirely due to some low form of fungous growth."

The species sent us were submitted to Professor Galloway, who gave them a careful examination, but was unable to discover any sign of fungous disease, except the sooty fungus (*Fumago salicina*), which is a very common accompaniment of scale or plant-louse injury, but seems to develop in the excretions of these insects and not to have any important bearing on their vitality. The failure to discover the cause of the mortality in some specific disease germ does not, however, preclude this explanation of the death of the scales, and if dying or affected specimens could be examined under sufficiently favorable conditions the disease germ could possibly be discovered. No other explanation of the death of the scales offers itself. Varying climatic conditions can hardly account for it, since the insect has shown a marked ability to thrive under climatic conditions of much greater variability in the East than it is ever subjected to on the Pacific Slope.

The use of contagious insect diseases to destroy important pests of the orchard or farm is a very attractive one, and has received much attention of late years, but, in spite of the notable claims made for it, particularly in the case of the chinch bug, the results so far obtained are far from demonstrating the complete practicability of this means of control. The subject, however, while still in the experimental stage, is one which is worth considering, and if there is any hope of benefit in this direction against the San Jose scale, the Eastern orchardists should certainly profit by it. We have therefore recently secured, through the kindness of Mr. John Scott, horticultural commissioner of Los Angeles County, Cal., a considerable quantity of dead and dying scales supposedly affected with this disease. Mr. A. F. Woods has conducted a careful examination of the material, at the instance of Mr. Galloway, to whom we referred it, and while the conclusions so far reached are not sufficient upon which to base a definite recommendation, there seems to be a specific disease which develops both in the insect and in its scale covering. We propose to follow up the matter, and if further investigation promises any practical outcome to take steps to introduce and disseminate the disease, if it be such, among the infested orchards and nurseries of the East.

REMEDIES AND PREVENTIVES.

CONFLICTING RESULTS BETWEEN WEST AND EAST.

Experience with different methods of destroying this scale, in both winter and summer treatments, early demonstrated that the methods reported as effective in California and other Pacific States, are comparatively valueless in the East. This is particularly true of the winter washes. This condition of affairs, which by the way was totally unexpected, may find a partial explanation in a variation in the habits of the insect. In California, especially in the southern part of the State, the development of the successive generations of the scale is not so completely interrupted by the winter season, and the scales, not so generally assuming the dormant condition and perhaps not developing so dense a scale covering, seem to be less resistant to washes, and to be amenable to strengths which in the East have been nearly without effect. Against this explanation it may be urged that a strong, vigorous growing scale will naturally be more resistant to the action of washes than a more or less completely dormant one whose vitality is reduced by long lack of food. Certain of our experiments, in fact, seem to suggest that this may be the case, although, on the whole, we are inclined to doubt it. A better explanation, therefore, probably lies in the fact that, in the use of winter washes, in which difference in results is particularly noticeable, these applications are made in California sometime before the rainy season begins, and hence have their full effect on the trees and the scales before they are washed off by rains.

In other words, the differences in precipitation and moisture between the two sections may be more influential in bringing about the failure of California winter washes in the East than are differences in temperature.

This noticeable difference in the effect of California washes on scales in the East was first discovered sometime ago by Mr. Marlatt in work upon other scale insects affecting fruit, notably in the case of the so-called West Indian peach scale (*Diaspis lanatus*). These results have since been repeatedly confirmed in experimentation against the San Jose scale.

Winter remedies, therefore, which are thoroughly satisfactory on the Pacific Coast are of very much less value in the East, where the winter is at all wet and severe at least, and it is therefore necessary in considering this subject to deal with the remedies for these two sections independently.

METHODS OF CONTROL IN CALIFORNIA.

The washes commonly recommended and for which notable success is claimed in California, are the lime-sulphur-salt solution, resin wash, and kerosene emulsion, ranking in estimation and common use in the order named. The lime-sulphur-salt wash is always employed during

the dormant season as a winter application. The resin wash is used both as a winter and a summer wash, chiefly the former. The kerosene emulsion is always used as a summer wash.

In addition to these, and more important perhaps than any of them, is the gas treatment, which, however, is not very extensively used against the San Jose scale, except on nursery stock.

The various washes named have been very carefully experimented with by Mr. Coquillett while an agent of this division, in California. The lime-sulphur-salt washes in the many combinations tried did not give as satisfactory results as was claimed for them by other experimenters, although notable benefit was secured. The resin wash was shown to be much preferable to the combination of lime, sulphur, and salt. In some cases, as will be shown later, other agencies than the washes seem to have effected the destruction of the scale. This is particularly true of what seems to be a scale disease, already referred to, which frequently causes the extermination of the scale over large districts, this result being attributed by various persons sometimes to the work of predaceous insects, and at other times to the use of washes which probably in themselves have little effect. The universal faith in the use of the washes named in California, however, gives them a standing which can not well be questioned. In this connection we quote from a letter received from Mr. H. B. Muscott, chairman of the San Bernardino County board of horticultural commissioners, giving the results of treatment with the washes and formulas commonly used. He says:

Five years ago we organized our commission under the laws of the State and started on a vigorous crusade to eradicate the scale and save our orchards. So successfully have we accomplished our work that from the reports of our inspectors just received there is not to-day so much of this scale in our entire county as was found in some individual orchards five years ago. I notice you are employing fumigation to eradicate the scale. We have also used it a little, but found it too cumbersome and expensive, and are relying almost wholly on washes sprayed on the trees while they are dormant. I inclose formulas of the washes we are using and have been using for two or three years past with gratifying success, when carefully prepared and thoroughly applied. My choice of these washes for the San Jose scale is first, the kerosene emulsion, and second, the lime-sulphur-salt solution.

The following are the formulas sent by Mr. Muscott. The washes are prepared by practical chemists employed by the commissioners and furnished at cost in concentrated form, with full directions for diluting and applying, a course which it would be highly desirable to adopt in the East with washes which are found to be successful.

METHODS OF PREPARING WASHES FOLLOWED IN CALIFORNIA.

Salt, lime, and sulphur solution.—Forty pounds of lime (unslacked), 20 pounds sulphur, 15 pounds coarse salt.

Add 40 gallons of water to the above materials, stirring thoroughly while the lime is slacking. Boil fully three hours, then add enough water to make 80 gallons of the solution, then strain through burlaps and apply milk warm. Use only on deciduous trees and when said trees are dormant.

Kerosene emulsion.—Five pounds of whale-oil soap, 5 gallons of kerosene.

Dissolve the soap in 10 gallons of boiling water, then remove from the fire and add the kerosene slowly, thoroughly churning the mixture in the meantime; then add enough hot water slowly to make the whole mixture 50 gallons, continuing the churning while adding the hot water. Apply milk warm for best results.

Sulphide of soda wash.—Two pounds of French sulphur; 1½ pounds of Greenbank caustic soda (or 1½ pounds Am. con. lye); 10 pounds of whale-oil soap. Boil the sulphur and caustic soda in 2 gallons of water for one hour; then dissolve the whale-oil soap in 10 gallons of boiling water. Add the two solutions together and boil for half an hour; then add enough water to make the whole mixture 50 gallons, and apply warm.

Resin wash.—Twenty pounds of resin; 5 pounds of Greenbank caustic soda (or 5 pound Am. con. lye); 2½ pints of fish or polar oil.

Dissolve the caustic soda in 10 gallons of boiling water; then add the fish oil and pulverize and add slowly the resin, and boil for four hours. Add enough hot water slowly to make the whole 100 gallons. Apply milk warm.

All of the above washes can be relied upon to exterminate the pernicious (or San Jose) scale on all kinds of deciduous trees, and all of them, except the salt, lime, and sulphur solution, can be depended upon to destroy the soft brown and black scale (when young) on citrus trees.

Salt, lime, and sulphur wash on a large scale.—In this connection we introduced the method of making the lime-sulphur-salt wash on a large scale given by Mr. H. P. Stabler, of Yuba City, Cal., in a paper read before the State Horticultural Society and reported in the Pacific Rural Press for February 4, 1893 (Insect Life, Vol. V, p. 280). By means of a 12-horsepower boiler and attached pipes, and a hot-water tank, some 1,500 gallons of spraying material were prepared in batches of 300 gallons each. Fifty pounds of lime and 100 pounds of sulphur were placed in vats of 300 gallons capacity, and 100 gallons of hot water were run in from the tank. After boiling, by turning on the steam for two or three hours, 150 pounds of lime and 75 pounds of salt were added, the former having been previously slaked. The contents of the vats were boiled for half an hour longer and water added to make 300 gallons. The different ingredients went into almost perfect solution, leaving a very slight sediment. The use of this mixture is reported to have resulted in the complete eradication of the San Jose scale in an orchard of 100 acres of 7-year-old trees.

FORMULAS RECOMMENDED BY THE DIVISION.

The method of preparation of kerosene soap emulsions, of the milk emulsion, and of the resin wash, now adopted by the division as a result of repeated experimentation, is appended. The methods given are strongly advised as most economical and satisfactory:

Kerosene and soap emulsion.—Two gallons kerosene; one-half pound whale-oil soap (or 1 quart soft soap); 1 gallon water.

Dissolve the soap in the water by boiling, and add boiling hot, away from the fire, to the kerosene. Agitate violently for five minutes by pumping the liquid back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. The mixture will have increased about one-third in bulk and assume the consistency of cream. Well made, the emulsion should keep indefinitely, and should be diluted only as wanted for use.

In limestone or hard-water regions "break" the water with lye before using to make or dilute the emulsion, or use rain water. Better than either, use milk emulsion, with which the character of the water does not affect the result.

Kerosene and milk emulsion.—Two gallons kerosene; 1 gallon milk (sour).

Heating is unnecessary; churn as in the former case for three to five minutes, or until a thick, buttery consistency results. Prepare the milk emulsion from time to time for immediate use, unless it can be stored in air-tight jars, otherwise it will soon ferment and spoil.

Resin wash.—Twenty pounds resin; 5 pounds caustic soda (70 per cent); 2½ pints fish oil; water, to make 100 gallons.

Ordinary commercial resin is used, and the soda that is put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (93 per cent) used, 3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in a kettle with water to cover them to a depth of 3 or 4 inches. Boil for one or two hours, occasionally adding water, until the compound resembles very strong, black coffee. Dilute to one-third the final bulk with hot water or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid without sediment, and should any appear in the stock mixture reheating should be resorted to. For a winter wash dilute one-third or one-half less.

THE HYDROCYANIC ACID GAS TREATMENT.

Wherever, as in California, it is necessary to treat orchards on a large scale, or the orchards of a county or fruit district, the use of the gas treatment is very strongly advised. In such cases the common custom on the Pacific Coast can not be improved upon, namely, putting the work of fumigation into the hands of parties who devote themselves to it entirely and fumigate orchards and trees at a regular rate. The expense and difficulty of making the application and the uncertainty of the proper use of the very dangerous chemicals in unaccustomed hands, together with the necessity of having these of a definite and tested strength, make it highly desirable for the fumigation to be done by experienced parties who can guarantee satisfactory results. In the use of the gas we have an especially economical means of treating nursery stock, and when properly done there is no method of ridding such stock of the San Jose scale which excels it in thoroughness. It is the usual method employed in the West for this purpose, and in the East has also recently been used successfully in cleansing nursery stock in New Jersey.

Judging from the results at Charlottesville, even the gas treatment may fail to destroy all the insects when the scales are densely massed, and in such cases a single fumigation can not be depended on.

The method of using the gas on orchard trees and on nursery stock may best be considered separately.

Method of fumigating orchard trees.—The treatment consists in inclosing the tree with a tent and filling the latter with the poisonous gas.

The tents should be of blue or brown drilling, or 8-ounce duck, painted or oiled, to make air-tight. The tent may be placed over small trees by hand and over large trees with a tripod or derrick. A tent

and derrick for medium-sized trees cost from $15 to $25; for a tree 30 feet tall by 60 feet in circumference, about $60.

Fused potassium cyanide (58 per cent pure[1]), commercial sulphuric acid, and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of acid, and 3 fluid ounces of water to every 150 cubic feet of space.

Place the generator (any glazed earthenware vessel of 1 or 2 gallons capacity) on the ground within the tent, and add water, acid, and cyanide, the latter in lumps, in the order named. Allow one-half hour for large trees or fifteen minutes for small ones. Bright, hot sunlight is apt to cause injury to foliage or new wood. This may be avoided by using tents of dark material, or working on cloudy days, or at night. One series of tents will answer for a county or large community of fruit growers.

Method of fumigating nursery stock.—In the case of nursery stock the treatment may be often given most economically and with the least possible trouble after the stock is removed and brought together for shipment. Large batches of stock can be heeled in, compactly tented over, and fumigated rapidly and with little difficulty. The dormant condition of the plants at this time will practically obviate any danger of serious effects of the gas on their vitality.

Mr. W. R. Gunnis, chairman of the San Diego County board of horticultural commissioners, writes us, under date of June 24, 1894, that in the case of his first experiment with this gas he treated 40,000 trees, nursery stock, averaging 8 feet high. These trees, which were badly infested with San Jose scale, were heeled in and fumigated by covering with large sheets and using several large generators, distributed according to size of the section of trees covered. No living scales have ever been reported on these trees since.

The possible use of a much greater strength of cyanide on dormant nursery stock is indicated by later experiments conducted by Mr. Gunnis and communicated to us in a letter dated January 30, 1896. He reports fumigating a very large lot of nursery stock after the manner just described, using, however, one ounce of cyanide of potassium 98 per cent pure for each 100 cubic feet of space to be filled by the gas. When a considerable space was included three or four generators were employed. For instance, in one section estimated to contain 4,000 cubic feet of space four generators were used, each containing 10 ounces of cyanide, 12 fluid ounces of sulphuric acid, and 30 ounces of water. These were placed in the passages between the trees, the cyanide and water being mixed first. The acid was added afterwards, beginning with the generator farthest from the opening and passing rapidly to the others, care being taken meanwhile not to breathe. The gas was allowed to act for one hour. The work was done in December at night, and the trees were afterwards set out in orchards. They were subsequently inspected several times and no living scales found on them.

[1] This strength should be guaranteed, or, preferably, shown by chemical analysis.

The very poisonous character of the potassium cyanide itself and of the hydrocyanic acid gas must be strongly impressed upon those who undertake to use this treatment for the first time. The cyanide must be kept where children and animals can not get at it; it must be kept in tightly closed vessels, and must be plainly labeled "Poison." During the process of treatment every possible care must be taken to prevent human beings or domestic animals from inhaling the gas.

EXPERIENCE WITH REMEDIES IN THE EAST.

DIFFICULTIES MET WITH.

Nearly fifty separate experiments were made with different washes at varying strengths in the course of the work of the division with remedies for the San Jose scale in the East. No difficulty was experienced in effecting the destruction of the young in summer, and for a day or two after hatching any of the ordinary washes and strengths recommended for scale insects are perfectly satisfactory. The difficulty is, however, that the continuous emergence of the young from a single female covers a period of six weeks, and to effect the extermination of the scales by the summer treatment necessitates applications practically every three days for nearly two months. This is ordinarily impracticable, and is much too expensive in time and material for general adoption. Remedial work with washes against the San Jose scale is therefore limited to winter operations, when the scale is dormant and all the individuals are in practically the same condition and can be reached by one or two applications.

The records of the experiments with winter washes conducted by the division at Riverside are appended to this section as a matter of record and for purposes of comparison.

VALUE OF THE DIFFERENT WINTER WASHES.

The following general conclusions will summarize the results obtained from the considerable series of experiments referred to:

(1) The Oregon and California washes are practically valueless under the conditions obtaining in Maryland, even at twice the strength reported to be effective on the Pacific Slope. They are without action on the health or fruiting of the plant.

(2) Lye washes are, in the first place, too expensive for use at the excessive strength required to accomplish any valuable results, and at this strength they also endanger the health of the plant. They do not seem to affect the blooming.

(3) Pure kerosene applied to the entire plant kills the scales, but unfortunately also the plant, at least in the case of peach.

(4) Kerosene and soap emulsion pure endangers the life of the plant. Diluted with one part of water it is not thoroughly effective, and this, with the trouble and expense of its preparation, renders its use inadvisable. Diluted with one part of water, or in greater dilution, it does not seem to affect fruiting or the health of the tree.

(5) Resin wash, to be effective, must be used at a strength involving an expenditure for materials which, with trouble and difficulty of its preparation, makes it of little practical value. Its effect on the health of the trees is not prejudicial, but in the stronger washes it prevents blooming the following season.

(6) Soap washes, particularly of whale-oil soap, have yielded the most satisfactory results, and at the rate of 2 pounds to the gallon, under the conditions of thorough drenching of the entire plant, with five or six days of subsequent fair weather, will destroy all the scales, whether applied in fall or in spring. The results with soap in less strength indicate that under the most favorable conditions the same result may be reached with mixtures containing only a pound and a half of soap, but as a matter of safety the stronger wash is always recommended. The action of the soap at the rate of 1 pound or more to the gallon, applied in the fall, is generally to limit blooming and fruiting the following spring, but the vigor and healthfulness of the tree are greatly increased. Applied in spring at the time of blooming, it does not injure the plant nor affect the setting of the fruit to any material extent in the case of the peach, and not at all in the case of the apple.

SOAP-WASH TREATMENT ON A LARGE SCALE.

Confirming the results of the preliminary experiments with soap washes is the outcome of a treatment on a large scale in the orchard at Riverside, Md., in which the previous experiments had been conducted. The entire orchard was sprayed with a wash containing for each gallon of liquid a pound and a half of whale-oil soap and half a pound of ordinary hard soap. The mixture was applied warm toward the end of April, 1895, when the peach trees of the orchard were in partial bloom and the apple trees were in full bloom and partly in leaf. No serious consequences resulted to the trees from their tender condition even in this early state of bloom and foliage. Above 95 per cent of the scales were dead on examination a few weeks later. When examined again in the fall of 1895, the effect was found to have been even more satisfactory, very few scales existing on the trees, which during the summer had made a very vigorous and satisfactory growth, showing considerable recovery from the previous serious damage done to them. If this application had been made in the fall at the time recommended, before the scales had become hardened for the winter, the results would possibly have been much more thorough, or would have approached complete extermination. The very successful outcome of the treatment on a large pear orchard at Chestertown, Md., is referred to on page 24. The results here obtained fully substantiate the claims made for the soap treatment. Other successful results following soap treatment are reported by Professor Smith (Entomological News, Vol. VI, p. 156).

GREATER VALUE OF THE SOAP WASH URGED.

The experiments as a whole indicate the vastly superior merit of the soap wash and its fall application. The greater vigor of the plant

resulting from the fall treatment more than offsets the possible failing of bloom. Owing to the impossibility of controlling weather conditions and the practical difficulty of wetting every part of the plant, one spraying can not often be relied on to accomplish the death of all the scales, but two conscientious drenchings may be expected to accomplish this result. These should be (1) at the time of or shortly after the falling of the foliage in autumn, and (2) just before blooming in spring.

DESIRABILITY OF A UNIFORM GRADE OF FISH-OIL SOAP.

The greatest difficulty with the soap washes, and one which must be obviated before uniform results may be hoped for, is in the varying strength and character of the soap used. No two brands of soap on the market are alike, and the differing results which are obtained by experimenters are undoubtedly due in large measure to the character of the soap itself, in connection, of course, with the varying climatic conditions. In addition to securing a good strong caustic soap, one is wanted which, at the strength employed on cooling, will not become a semisolid or glutinous stringy mass, as do most of the ordinary soaps and also many of the fish-oil soaps of more recent manufacture. The old whale or fish oil soap employed in the original experiments could be sprayed in solution cold at 3 pounds to the gallon, and this is a most necessary characteristic. It is highly desirable, therefore, that soap makers should be encouraged to undertake the manufacture of a definite brand of soap which can be relied upon to be uniform in composition and strength, and if possible to have some supervision by State or national authorities to insure such results.

VARYING RESULTS AND EFFECTS OF WASHES ON TREE AND INSECT.

In the treatment of trees with soap washes and other insecticides a number of interesting conclusions were reached, explaining the varying results found on different parts of the tree, the effect of the washes on the health of the tree and on the fruit, and the effect of the washes on the scales themselves. These conclusions will be of interest. They relate particularly to the experiments conducted by the division.

Varying results on different parts of the same tree.—Where the scales are thickly massed on the older and lower parts of the trunk, a wash is apt to be more efficient, and frequently in these situations scarcely a scale will survive, while on the extremities of the branches, where the scales are scattering, the percentage of living ones is greatly increased. This is evidently due to the fact that the smooth terminals, especially those of peach, do not retain much of the wash, and lose it more readily under the action of rains; also that insects in these situations are better nourished and perhaps more vigorous than where more thickly clustered. The dense incrustation of the scales on the bark produces also a roughness which holds the wash, and the latter naturally accumulates also on the basal portion of the branches.

A certain patchiness in result is often noted. In other words, on particular branches or sides of branches every scale will be destroyed,

while elsewhere a considerable percentage of living scales will be found, sometimes confined to small areas. This is due either to a failure to drench the tree evenly or else to the action of subsequent rains and snows. The latter causes affected in this way some midwinter experiments conducted by us, which in one instance were followed by a light rain of a few minutes' duration from the northwest, and in another were affected by the irregular melting of snow, which lodged to a considerable extent in the trees.

These facts afford an additional reason for making the treatment early in the fall, so that the wash may act over as long a period as possible, since at this season rains are usually much less frequent than they are in mid or late winter or early spring.

Action of insecticides on dormant scales.—An examination of the records of these experiments, in connection with results with other scale insects, strongly emphasizes the point that in the dormant resting condition scale insects respond to insecticides very slowly and gradually, and this has an important bearing on the determination of the usefulness of an application. The scale larvæ during the growing season are killed in a few minutes, or a few hours at furthest, just as are other soft-bodied insects, but the mature scale does not exhibit the effect of the wash for some time unless it be so radically strong as to be unnecessarily expensive or as to endanger the life of the plant. We found that little could be judged of the ultimate result within two weeks, and at the end of a month the estimate could be only a provisional one, while at least two months were necessary to reach approximately final conclusions.

The slow and progressive death of the scales must be largely due to the gradual penetration of the insecticide, and also indirectly to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

It was noted, also, that it is the destruction of the last 5 or 6 per cent of the scale insects which necessitates the great strength of the wash and the accompanying heavy expense. It is comparatively easy to kill 75 to 90 per cent of the scales, and this with comparatively weak and inexpensive washes, but to reach the remaining few, double or treble strength is required.[1]

Effect of the washes on the health of the tree and on fruiting.—With some of the stronger washes, particularly those of soap and resin, a marked diminution is shown in the amount of bloom and in the fruit set. This, however, is usually accompanied by an increase in the amount of foliage. This was very marked in the case of the trees treated with the stronger whale-oil soap washes, which were noticeably

[1] This is illustrated notably in the resin wash experiments against *Diaspis lanatus* in the winter of 1894–95, where a double summer strength killed 90 per cent; an application twice as strong, only 95 per cent; and one three times as strong, or six times summer strength, was necessary to effect complete extermination.

vigorous in foliage, and presented an exceptionally fine appearance, but bore scarcely any fruit. An application of soap made late in spring, or after the trees were already blooming, did not seem to affect seriously the setting of the fruit in the case of the peach, and in the case of the apple no injury whatever was noted, even where applied at the rate of 2 pounds to the gallon, with the trees in full bloom.

The pure kerosene emulsion has a disastrous effect on the trees, and pure kerosene killed outright the trees treated with it.

The lye washes injure the new growth if strong enough to be of any value against the scales; and the lime, sulphur, and salt washes are practically without effect upon the plant and kill comparatively few scale insects.

BEHAVIOR OF DIFFERENT WASHES AND THEIR COST.

The diluted washes presented no difficulties in application, nor is there any trouble in applying the Oregon and California washes at twice the ordinary strength. Pure kerosene emulsion can not be very satisfactorily sprayed with an ordinary nozzle, as it is too thick for this purpose. The strongest resin wash may be applied hot with an ordinary nozzle, but on cooling the resin will separate out within an hour or two, hence the necessity, if used at great strength, of applying the liquid hot. Whale-oil soap washes, even at 3 pounds to the gallon, are thin enough when cool to be sprayed without much difficulty, and no trouble whatever was experienced with 1½ to 2 pounds to the gallon. The common hard soap used in experiments, solidified almost immediately into a rather tenacious soft soap, even at 1 pound to the gallon, and in this or greater strengths could not be sprayed except at high temperatures. When once on the tree, however, it adheres much better than fish-oil soaps, or at least the evidence of its presence on the tree is much more apparent, the whitening of the bark being noticeable for months afterwards. Whale-oil soap used did not give this marked appearance to the tree, and even at the start the tree remained only somewhat darker, as though wet.

The cost of the stronger applications are approximately as follows:

Whale-oil soap, at 4 cents per pound, using 2 pounds to the gallon, gives an 8 cents per gallon wash. It was found impossible to make a soap by buying the ingredients any cheaper than it could be obtained from the soap manufacturers.

Resin wash at six times summer strength costs about 6 cents per gallon by buying the ingredients in wholesale lots, viz, lye in drums of 800 pounds capacity, and the resin and oil by the several barrel lots. This does not include the expense of preparation, which is considerable.

Kerosene at 6 cents per gallon for a cheap grade, with soap at 4 cents per pound, would represent a cost for the pure emulsion of a little less than 5 cents per gallon, and for the once diluted mixture, 2½ cents.

The crystal potash lye was secured at retail and cost 15 cents a pound, making the strongest wash applied cost 30 cents a gallon.

SUMMARY OF RECOMMENDATIONS.

We have discussed the subject of remedies and preventives as applying to different sections of the country and as affected by varying climatic conditions somewhat in detail, both as a matter of record and to give an intelligent comprehension of the present information on the subject, and also to furnish an adequate basis for future experimentation. It remains to sum up in brief the results so far gained.

For the Pacific Coast the experience of years has given confidence in treatment and washes suitable to the climatic conditions there obtaining and now generally used and well understood.

For the East, experience justifies the following steps as of highest importance:

(1) In all cases of recent or slight attack the affected stock should be promptly uprooted and burned. No measure is so sure as this, and the danger of spread is so great that this course seems fully warranted.

(2) In cases of long standing and wide extent the affected stock should be cut back severely and treated with winter soap wash. Stock badly incrusted with scale should be cut out at once and burned. The lessening of the vitality, together with the poisoning of the sapwood already effected by the scale in such cases, will usually prevent the plant from ever again becoming healthy, and generally it is beyond help. We wish particularly to impress upon the minds of fruit growers that as soon as this insect is found to occur in an orchard the most strenuous measures must be taken to stamp it out. No halfway steps will suffice. The individual must remember that not only are his own interests vitally at stake but those of the entire community in which he resides. He may think that he can not bear the loss, but the loss in consequence of the slightest neglect will be much greater. The fact, too, that there is a community of interests among fruit growers in this matter must not be lost sight of. Fruit growers must be mutually helpful in an emergency like this.

(3) As precautionary measures to prevent the introduction of the scale into new districts, the following considerations are important: No orchardist should admit a single young fruit tree or a single cutting from a distance into his orchard without first carefully examining it and satisfying himself conclusively that it does not carry a single specimen of the San Jose scale; he should insist, also, on a guaranty from the nurseryman of such freedom. In addition, no fruit should be brought upon the premises without previous careful inspection. If this course is adopted by everyone interested, without exception, the rate of spread of the species may be limited to the comparatively slight natural extension by crawling, by winds, and by the aid of other insects and birds.

RECORD OF EXPERIMENTS WITH WINTER WASHES.

Dates of, and conditions following treatment.—The applications were made at four different times, as follows:

The first series was made on October 25 and 26, 1894, and comprised experiments 1 to 5. The trees at this time were still in leaf, but the foliage was mature and ready to fall.

The second series was made November 17, and included experiments 6 to 9. Subsequent to these applications (series 1 and 2) the weather conditions were very favorable, no rains occurring for some days, and in fact the months of October and November, 1894, were exceptionally dry.

Unless otherwise noted, the applications were all made to peach trees.

Whale-oil soap.

Experiment 2:

October 25, 3 pounds soap to the gallon of water; November 17, fatal to all scales; December 16, above result confirmed by subsequent examination; May 4, no living scales found on tree, nearly all dead scales washed off by action of rain; tree in exceptionally vigorous condition, and with luxuriant foliage, but with only one or two fruit set. Adjoining trees in full fruit, but very much inferior in general appearance and in development of foliage.

Experiment 1:

October 25, 2 pounds soap to the gallon of water: November 17, fatal to all scales; December 16, same result confirmed by additional examination: May 4, 1895, tree in exceptionally vigorous condition, but without fruit.

Experiment 43:

January 24, 1895, same strength as preceding; March 11, fatal to 95 per cent of the scales; May 4, 95 per cent of scales on living portion of tree killed. Half the tree dead, evidently from the scale, with which it was thickly incrusted. Living portion of the tree in full leaf, but without fruit.

Experiment 10:

December 15, 1½ pounds to the gallon: January 17, fatal to 90 per cent of the scales; March 11, 5 per cent living; May 4, not above 5 per cent of scales living. Tree in leaf and healthy, but without fruit.

Experiment 34:

January 23, 1½ pounds of soap to the gallon; March 11, fatal to 90 per cent of the scales: May 4, less than 5 per cent of the scales living; only 2 healthy scales found. Tree originally very heavily infested; some of the branches killed, evidently from the effects of the scale; others vigorous, but without fruit.

Experiment 46:

January 24, same strength as last; March 11, fatal to 90 per cent of the scales; May 4, tree dead, with the exception of two vigorous branches or new shoots of last year's growth. On these branches 10 per cent of the scales are living.

Experiment 35:

January 23, 1½ pounds to the gallon; March 11, fatal to 90 per cent of the scales; May 4, 5 per cent of the scales living, limited to terminals. Trees vigorous and in fruit.

Experiment 11:

December 15, 1 pound of soap to the gallon of water: January 17, fatal to 80 per cent of the scales; March 11, but 10 per cent of the scales living; May 4, 10 per cent of the scales alive (on terminals). Tree in good condition and in fruit.

Experiment 44:

January 24, same strength as last; March 11, fatal to at least 70 per cent of scales; May 4, 85 per cent of scales dead. Tree in vigorous condition, with fruit.

Experiment 45:

January 24, same strength as last and yielding the same results.

Experiment 36:

January 23, ¾ pound of soap to the gallon of water; March 11, fatal to about 70 per cent of the scales; May 4, 85 per cent of the scales have succumbed. Tree vigorous, with the exception of two branches, which are evidently killed by the scale; the whole tree originally densely infested; fruit in very small quantity.

Experiment 12:

December 15, ½ pound of soap to the gallon; January 17, fatal to about 50 per cent of the scales. Tree afterwards subjected to the general treatment given the orchard.

Experiment 37:

January 23, ⅜ pound to the gallon; March 11, upward of 50 per cent of scales killed. Tree afterwards subjected to general treatment given the orchard.

Hard laundry soap.

Experiment 18:

December 16, 2 pounds to the gallon; January 17, fatal to 85 per cent of the scales; March 11, no living scales could be found after extensive examination; May 4, in patches, a few living scales found; more than 97 per cent killed. Tree was originally very heavily incrusted with scales, and about one-half the branches are dead, probably from this cause; no bloom or fruit present.

Experiment 19:

December 16, 1½ pounds of soap to the gallon; January 17, fatal to 85 per cent of the scales; March 11, no living scales found, except two, in doubtful condition; tree still whitened with the soap; tree originally densely incrusted; May 4, fatal to at least 95 per cent of the scales; tree uninjured, but without bloom or fruit.

Experiment 20:

December 16, 1 pound of soap to the gallon; January 17, fatal to 60 per cent of the scales; March 11, but 10 per cent of the scales remain alive; May 4, percentage of living scales unchanged; tree uninjured and with fruit.

Experiment 21:

December 16, ½ pound of soap to the gallon; January 17, fatal to about 20 per cent of the scales; tree was subsequently subjected to additional treatment.

Experiment 22:

December 16, ¼ pound to the gallon; January 17, fatal to about 10 per cent of the scales; tree subsequently subjected to general treatment given the orchard.

Home-made fish-oil soap.

Experiment 15:

December 16, 1½ pounds of soap to the gallon; January 17, fatal to 50 per cent of the scales; May 4, fatal to about 75 per cent of scales; tree in leaf and fruit, vigorous.

Experiment 16:

December 16, 1 pound of soap to the gallon; January 17, fatal to about 20 per cent of the scales. Tree subsequently subjected to general treatment given the orchard.

Experiment 17:

December 16, one-half pound of soap to the gallon; January 17, fatal to only about 5 per cent of the scales; March 11, more than 50 per cent of the scales living. Tree afterwards subjected to general treatment given the orchard.

Resin wash.

Experiment 13:

December 15, six times strength of summer wash; applied to an apple tree very warm, almost scalding hot; January 17, examination indicated the death

of all the scales, some of which were not yet completely dried up; March 11, no living scales found; May 4, most careful and extended examination resulted in discovering 4 living scales; tree vigorous, but without bloom; trees on either side in bloom, but other trees in neighborhood, untreated, also without bloom.

Experiment 31:

January 23, same strength as last, applied warm; March 11, fatal to 95 per cent of the scales; May 4, tree killed, except one vigorous shoot of last year's growth, springing from near base; tree densely incrusted with scales, and its death probably due to this fact; scales on the living branch not very numerous and no living ones found.

Experiment 14:

December 15, four times strength of summer wash; January 17, fatal to 85 per cent of the scales; March 11, but 5 per cent living; May 4, all but the new growth of last year dead, evidently from the scales which densely incrust the bark; fruit is set in one or two instances on the living portion; on the entire tree 95 per cent of the scales are killed.

Experiment 32:

January 23, same strength as last; March 11, fatal to 90 per cent of the scales; May 4, tree healthy, with scattering fruit; not above 10 per cent of the scales living, and these confined to the terminals.

Experiment 5:

October 25, twice summer strength. This experiment was ineffective, the resin having separated out somewhat, and the wash was therefore much weaker than intended. Tree afterwards subjected to the general treatment given the orchard.

Experiment 33:

January 23, same strength as last; March 11, fatal to 75 per cent of the scales. Tree afterwards subjected to general treatment given the orchard.

Kerosene oil.

Experiment 42:

January 23, application made to two trees, one badly incrusted with scales, the other a vigorous tree, less infested; March 11, fatal to all the scales: May 4, both trees dead.

Kerosene emulsion.

Experiment 23:

December 16, undiluted emulsion; January 17, fatal to 90 per cent of the scales, a few on terminals apparently living; May 4, all scales dead except in isolated spots, evidently where the wash did not reach; tree dead or dying, except one limb, which is in leaf and fruit, but this also will probably not survive the present season; this result due partly to the wash, although greatly assisted by the dense scale incrustation.

Experiment 38:

January 23, same strength as last; March 11, fatal to all scales; May 4, tree dead, with the exception of one or two branches, which are making feeble effort to leaf out. Tree originally badly infested, but not enough so to have caused death, which must soon result.

Experiment 24:

December 16, emulsion diluted with 1 part water; January 17, fatal to 80 per cent of the scales; May 4, only some half dozen scales found after careful examination; about 98 per cent killed: tree in full leaf and fruit.

Experiment 39:

January 23, same strength as last; March 11, fatal to 95 per cent of the scales; part of the tree vigorous, uninjured, and in full leaf, with some fruit; remainder dead, probably from the effect of the scales; some few living scales on terminals, perhaps 5 per cent.

Experiment 25:

December 16, emulsion diluted with 2 parts water; January 17, fatal to 50 per cent of the scales. Tree afterwards subjected to general treatment given the orchard.

Experiment 40:

January 23, same strength as last; March 11, fatal to 75 per cent of the scales; on some parts of the tree all the scales were killed; May 4, tree dead, probably from effect of scales and borer. Effects of latter were very marked about base of tree. The tree was also densely incrusted with scales.

Experiment 26:

December 16, emulsion diluted with 3 parts water; January 17, fatal to about 30 per cent of the scales. Tree afterwards subjected to general treatment given orchard.

Experiment 41:

January 23, same strength as last; March 11, fatal to 75 per cent of scales; May 4, tree dead, with the exception of new shoot of last year's growth from near base; scales dead on this branch, which was not in very healthy condition, and the experiment has therefore little value.

Experiment 3:

October 25, emulsion diluted with 4 parts water; November 17, not very effective. Tree afterwards subjected to general treatment given orchard.

Experiment 4:

October 25, emulsion diluted with 6 parts water. Result as in preceding experiment. Tree afterwards subjected to general treatment given orchard.

Concentrated crystal potash lye.

Experiment 27:

December 16, 2 pounds lye dissolved in a gallon of water; January 17, fatal to 85 per cent of scales; March 11, fatality estimated at nearly 80 per cent; May 4, about 15 per cent of scales estimated to be living, the living ones occurring somewhat in patches; tree in leaf and fruit, not especially injured, though some of the smaller terminals died after blooming; this and the other trees treated with lye present a beautiful, bright, clean appearance, and have a very noticeable red color.

Experiment 28:

December 16, 1 pound to the gallon; January 17, fatal to 75 per cent of the scales; March 11, no change in condition noted. Tree afterwards subjected to general treatment given the orchard.

Experiment 29:

December 16, one-half pound lye to the gallon; January 17, fatal to upward of 50 per cent of the scales. Tree afterwards subjected to general treatment given the orchard.

Experiment 30:

December 16, one-fourth pound lye to the gallon; January 17, fatal to 20 per cent of the scales. Tree afterwards given general treatment.

Oregon wash.

Experiment 6:

November 17, ordinary strength (sulphur 15 pounds, slaked lime 15 pounds, bluestone 1¼ pounds, water to make 100 gallons); December 15, fatal to only a small percentage of the scales. Tree afterwards subjected to general treatment given the orchard.

Experiment 7:

November 17, double strength; December 15, fatal to very small percentage of scales; May 4, tree still whitened with wash; larger scales, representing at least 50 per cent, alive.

California wash—Lime-salt sulphur.

Experiment 8:

November 17, ordinary strength (sulphur 25 pounds, lime 50 pounds, salt 18 pounds, water to make 100 gallons); December 15, fatal to only a small percentage of scales. Tree afterwards subjected to general orchard treatment.

Experiment 9:

December 15, double strength; fatal to very inconsiderable percentage of the scales. Tree afterwards subjected to general treatment of the orchard.

THE NURSERY QUESTION.

One of the most important and difficult questions connected with the appearance over a wide district in the East of the San Jose scale is the bearing it has on the Eastern nurseries, especially the very important ones in New Jersey in which the scale is known to have long existed and from which it has already been widely disseminated. The introduction of the scale into these nurseries was undoubtedly unintentional, and the owners were unquestionably ignorant of the amount of damage they were doing to Eastern fruit growers. Few people in the East have hitherto realized the importance of the damage which scale insects may work to fruits, and in view of this general ignorance the nurserymen in question could not have been expected to exercise much greater precautions than they did. Whether blamable or not, they will unquestionably suffer very seriously from the widespread injury caused by the Eastern occurrence of this scale, and this is true not only of the nurseries directly concerned, but of others within the infested district. The practical question comes up here whether it is safe for purchasers to secure stock from any of these nurseries. The Eastern fruit grower now fully realizes the immense danger which the introduction of this insect on his premises means to him, and he will not be apt to take undue risks in making purchases from doubtful sources. It is also practically impossible for even an expert entomologist to be certain that the scale is entirely exterminated in an infested locality. No examination can be so thorough as to make it impossible that not an individual scale has been overlooked, and the wide range of food plants makes it always possible for the scale to be reintroduced from near-by sources. If also a fertilized female be peculiarly protected by bark or by overlapping scales, and survive treatment either with insecticides or fumigation, it is a question of only a few years before the orchard or nursery will be more or less completely restocked with scales.

In the case of stock once infested, therefore, no absolute guaranty of freedom from this scale can be given, even by an expert, and any such guaranty is very apt to deceive the purchaser. The only safe course is to demand from the nurseryman a written certificate that the stock has never been infested or subject to infestation, and further, that he will assume the responsibility for the subsequent damage, should his belief in the cleanliness of his stock prove ill founded. The patronage given to nurserymen should be in proportion to their evident

interest in this regard and the earnestness of their efforts to remedy the evil already done. We suggest the following form of certificate or guaranty for the consideration of nurserymen and purchasers:

We hereby guarantee the nursery stock sent out herewith to have been at no time infested with the San Jose scale, to be free from other injurious insects, and to be in vigorous, healthy condition.

We further agree, in case any or all of said stock be found within one year from date of delivery to be infested with the San Jose scale, to replace the same with sound stock without cost to the purchaser.

The fixing of the responsibility on the nurserymen may perhaps be best secured by State legislation, but if all the facts are disseminated and the public fully informed of the action taken by various nurseries the loss of trade resulting from the neglect of proper precautions will, as pointed out by Professor Fernald, be of itself a most powerful incentive to such precaution.

The responsibility of the nurseryman should extend not only to his own stock, but to all stock which he handles in fulfilling his contracts or those of his agents. It is a common practice among nurserymen to send out agents, who contract for the supply of particular varieties of trees, and if the firms they represent are unable to fill these contracts the trees are secured from any other available source. As a result of this practice reports have come to us of infested material as from a particular nursery, but when an examination of this nursery was made it was found that no infested stock of that particular kind was grown there, the infested material having been secured from some other nursery to fill contracts. In a case of this kind the nursery through which the sale was made should undoubtedly be held responsible for the introduction of the scale in his relation with the last purchaser.[1]

LEGISLATION.

The necessity for appropriate State legislation to enforce insecticide work and to provide for the inspection and quarantining of infested trees or other nursery stock on which the insect may be introduced has already been suggested as a possible aid to the control of the San Jose scale, particularly as facilitating the stamping out of the insect in the East and preventing its spread to new localities. The subject of insect legislation has been brought more strongly than ever to the attention of agriculturists and horticulturists in the East by the outbreak of the San Jose scale, and in two States (New York and New Jersey) recent steps have been taken to secure the passage of such laws, and we are informed (January 13, 1896) by Commissioner Thomas Whitehead that

[1] While this bulletin is going through the press we have received the Annual Report of the American Association of Nurserymen for 1895, and are pleased to see that the leading nurserymen of this country take a broad and sensible view of the San Jose scale question. By a unanimous vote they approved and commended the full statement of the facts concerning infested nurseries presented to the association by Prof. F. M. Webster, and published the information entire.

the Virginia legislature will soon have a bill before it on this subject. After a careful survey of the possibilities, and judging from the history of similar legislation in the past, we are forced to admit that in spite of the considerable good they may accomplish such laws in general are apt to be of secondary importance, since they must depend for their enforcement almost entirely upon the interest taken by the community as a whole. Without a strong public sentiment back of them they will necessarily fail. Where the danger is strongly felt, however, and the great majority of the people are urgently in favor of taking all possible steps to secure protection, the existence of an adequate law will be an invaluable means of compelling action on the part of indifferent nurserymen or fruit growers, who otherwise would remain a continual menace to their neighborhoods and the country at large.

In answer to an anticipated demand for information on the subject of legislation against injurious insects a special bulletin[1] was published by the Department, giving a compilation of all recent legislation in the several States of the Union against injurious insects, and this bulletin will be of considerable assistance to any agricultural or horticultural societies which may be desirous of securing legislation of this nature on the part of their respective States.

As suggestive of what may be done in the matter of legislation the only law known to us which is specifically aimed at the San Jose scale is here given. It is a law drafted by Dr. Lintner and presented before the New York legislature at its session of 1894–95. Its passage, as we have elsewhere stated, will not be urged during the present session.

NEW YORK.

AN ACT to provide for the extermination of the San Jose scale in the State of New York.

The people of the State of New York, represented in senate and assembly, do enact as follows:

SECTION 1. Whenever the State entomologist may have knowledge of the existence of the San Jose scale, or has reason to believe in the probability of its existence in any locality within the State of New York on any trees, plants, vines, or fruit, he shall notify the commissioner of agriculture, who shall thereupon appoint one or more experts who shall be sufficiently familiar with the scale to be able to recognize it, for the prompt inspection of the infested or suspected locality.

SEC. 2. Such agent shall make thorough inspection of the locality named, and if the existence of the scale is found therein he shall notify the owner or owners of the orchard, nursery, or grounds in which the insect is found of its existence therein, and serve a notice containing a statement of all the facts found to exist upon the owner or owners, with an order that within ten days they shall take such measures as have been proven to be effectual in the destruction of the scale and for prevention of its further distribution, and to continue them until its extermination has been effected.

SEC. 3. If the owner or owners shall refuse to comply with the order of the agent, as above stated, the agent shall be charged with its execution, and for this purpose

[1]Bull. 33, U. S. Dept. Agr., Div. Ent. Legislation against Injurious Insects; a Compilation of the Laws and Regulations in the United States and British Columbia. By L. O. Howard.

shall employ all necessary assistance; and such agents or his employees may enter upon any or all premises within the town or city for the purpose of the speedy extermination of the scale. Such agent shall be entitled to compensation for his services under this act at the rate of five dollars for each full day spent by him in the discharge of his duties and the necessary disbursements paid or incurred by him therein.

SEC. 4. The sum of five thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of the State treasury to carry out the provisions of this act.

SEC. 5. This act shall take effect immediately.

THE SALE OF INFESTED FRUIT.

The main omission in the proposed New York law quoted above is that there is no provision regarding the sale or the exposure for sale of fruit bearing the San Jose scale. One of the most important regulations of the California State board of horticulture is their rule 6, adopted August 15, 1894, although a practically similar provision had been previously in operation. This rule reads: "Fruit of any kind, grown in any foreign country, or in the United States or Territories, found infested with any insect or insects, or with any fungi, blight, or other disease or diseases injurious to fruit or to fruit trees, or to other trees or plants, is hereby prohibited from being offered for sale, gift, or distribution within the State." We have already shown that the San Jose scale may be spread through the scattering of fruit parings at certain seasons of the year, and any legislation which is drafted with this insect in view should contain some such rule as the one just quoted.

The finding, by Dr. Smith, of California pears in Brooklyn containing adult scales and living young was followed by other discoveries of the same character in Philadelphia and New York, and one of us has already called attention to the peculiar condition of affairs which renders a California fruit dealer liable to fine if he offers for sale in his own town a crate of pears bearing this scale insect, but which makes no provision for a penalty if he has boxed up his crate and shipped it to some Eastern city. (See Insect Life, Vol. VII, p. 335.) We are not certain that the scale has established itself in any locality in the East as the result of this shipment of California fruit, but such an establishment is at all times possible. We have corresponded with the president of the California State board of horticulture with reference to this matter, and have his assurance that an effort will be made to alter the California regulations so as to prevent this everyday evil.

BIBLIOGRAPHY OF THE SAN JOSE SCALE.

[Chronologically arranged.]

COMSTOCK, J. H.—Report Commr. Agriculture, 1880, pp. 304–305, Pl. XII., fig. 7.
Original description of *Aspidiotus perniciosus*.

COOKE, MATTHEW.—Treatise on insects injurious to fruit and fruit trees, 1881, pp. 33–34.
Description of San Jose scale.

CHAPIN, S. F.—(Letter in) Report Commr. Agriculture, 1882, pp. 207–208.
Concentrated lye remedy for San Jose scale.

COOKE, MATTHEW.—(Note in) Report Commr. Agriculture, 1882, pp. 65, 208.
Reports the successful use of coal oil and lye as remedies for the San Jose scale.

COOKE, MATTHEW.—Insects injurious to the orchard, vineyard, etc., 1883, pp. 60–63, figs. 15–21.

CHAPIN, S. F., *et al.*—Discussion at Third State Fruit Growers' Convention, November, 1883. Report California State Board of Horticulture, 1883, p. 91. (1883?)
Concentrated lye, 1 pound to a gallon of water, generally considered the best wash for San Jose scale.

CHAPIN, S. F.—Bulletin No. 2, State Board of Horticulture. Report California State Board of Horticulture, 1884, pp. 22, 34, 35, 42. (December 31, 1884.)
Recommends a mixture of whale oil, concentrated lye, tobacco, sulphur, coal oil, and sulphate of iron (called "whale-oil and iron compound") as an effective summer and winter wash for San Jose and other scales.

KLEE, W. G.—Report of the California State Board of Horticulture, 1885–86, 1887, pp. 373–375, Pl. I.
Habits of, and remedies for, the San Jose scale.

KLEE, W. G.—Insects preying on scale insects. Report as Inspector of Fruit Pests in Report California State Board of Horticulture, 1885–86 (1887), p. 404.
Reports *Chilocorus bivulnerus* as attacking San Jose scale; figures the ladybird.

KLEE, W. G., Messrs. HATCH, BUCK, BLOCK, *et al.*—Report California State Board of Horticulture, 1885–86 (1887). (Discussion at Sixth Annual State Fruit Growers' Convention.)
Potash and caustic soda; resin, potash, and soap; salsoda and whale-oil soap, etc., discussed as remedies for San Jose scale.

BOGGS, W. M.—Report as Inspector of Fruit Pests (to April 15, 1886). Report California State Board of Horticulture, 1885–86 (1887), p. 12.
Reports appearance of San Jose scale as far north as Geyserville, Sonoma County, Cal.

ROSE, L. J., JOHN BRITTAN, G. N. MILCO, *et al.*—Report State Board of Horticulture, 1885–86 (1887). (Discussion at Fifth Annual State Fruit Growers' Convention.)
Brine, potash fertilizers, etc., discussed as remedies for San Jose scale at pp. 40, 41, and *passim*.

KLEE, W. G.—Report Inspector Fruit Pests. Report California State Board of Horticulture, 1887–88, p. 245, Pl. I.
Brief description; species of trees affected; natural enemies (remedies *l. c.*, p. 256),

KLEE, W. G.—The pernicious scale. Treatise on the Insects Injurious to Fruit and Fruit Trees of California, pp. 10, 11, fig. 2 and Pl. I (October 12, 1888)
Brief description and note on habits.

LELONG, B. M.—Pernicious scale. Report California State Board of Horticulture, 1889, p. 170 (1890).
Brief description with formulæ for summer and winter washes.

RILEY, C. V., and L. O. HOWARD.—Reply to letter of Wm. M. Freeman. Insect Life, Vol. III, p. 69 (September, 1890).
Recommend kerosene emulsion or resin wash.

KERCHEVAL, A. F. and F. E. GRAY, president and secretary Los Angeles County horticultural commission.—Report published in Los Angeles Evening Express, March 5, 1890; also Insect Life, Vol. II, p. 312.
Discusses securing parasites of the San Jose and other scales which is announced to be the policy of the commission.

FREEMAN, WM. M. (Walla Walla, Wash.).—*Aspidiotus perniciosus* in orchard of J. M. Gose (letter). Insect Life, Vol. III, p. 68 (September, 1890).
First noticed on trees bought from a New York State nurseryman.

GREGORSON, D.—Scale insects in California (letter). Insect Life, Vol. III, p. 169 (November, 1890).
San Jose scale abundant at Riverside, Cal., in July, 1890.

COLLINS, W. E.—Insect pests and the laws therefor. Report California State Board of Horticulture, 1890, p. 49 (December 30, 1890).
Necessity for quarantine laws against San Jose and other scales; cooperation necessary to enforce such laws.

COQUILLETT, D. W.—Report for 1890. Bulletin 23, Div. Entom., pp. 19-36 (January, 1891).
Discusses gas treatment, resin wash, lime-salt-sulphur wash, and other remedies for San Jose scale.

RILEY, C. V., and L. O. HOWARD.—Matters in California. Insect Life, Vol. III, p. 426 (June, 1891).
Refers to fining of a fruit dealer at Riverside for selling fruit infested with San Jose scale.

RILEY, C. V., and L. O. HOWARD.—New entomological society. Insect Life, Vol. III, p. 487 (August, 1891).
Reviews a paper by E. M. Ehrhorn, in which is recorded the rearing from San Jose scale of *Coccophagus citrinus* Craw.

RILEY, C. V., and L. O. HOWARD.—A criticism of Circular No. 1 of this Division. Insect Life, Vol. IV, p. 83 (October, 1891).
Relative value of resin and lime-sulphur washes for San Jose scale.

LELONG, B. M.—Report California State Board of Horticulture for 1891 (1892), pp. 196, 198, 199.
Remedies.

CRAW, ALEXANDER.—Report California State Board of Horticulture for 1891 (1892), p. 285.
Remedies for, and parasites of, San Jose scale.

COQUILLETT, D. W.—Report on the scale insects of California (1891). Bulletin 26, Div. Entom., pp. 21-25 (January, 1892).
Discusses food plants and parasites of the San Jose scale, and lime-salt-sulphur wash and resin wash as remedies.

CRAW, ALEXANDER.—Insect friends and foes. Report California State Board of Horticulture, 1891, p. 285 (January 23, 1892).
Thinks *Aphelinus fuscipennis* cleared an orchard near Los Angeles of San Jose scale.

RILEY, C. V.—Report of the Entomologist for 1891, p. 244 (1892).
Discusses washes used in California.

TOWNSEND, C. H. TYLER.—Scale insects in New Mexico. Bulletin 7, New Mexico Agricultural Experiment Station, pp. 6, 7 (June, 1892).
Records the species at Las Cruces, N. Mex.

OLLIFF, A. SIDNEY.—Agricultural Gazette of New South Wales, September, 1892, pp. 698, 699.
On pear in New South Wales. (Mentioned in Insect Life, Vol. V, p. 214, April, 1893).

RILEY, C. V., and L. O. HOWARD.—Good work of the twice-stabbed ladybird. Insect Life, Vol. V, p. 53 (September, 1892).
Records, on authority of California Fruit Grower, clearance of orchards in Tulare County, Cal., by *Chilocorus bivulnerus*.

RILEY, C. V.—An Australian Scymnus established and described in California. Insect Life, Vol. V, p. 127 (November, 1892).
Records *Scymnus lophanthæ* as attacking the San Jose scale.

KOEBELE, ALBERT, and ALEXANDER CRAW. Report on the Importation of Parasites and Predaceous Insects [into California], pp. 15 (1892).

Mentions the work of *Orcus chalybeus*, *O. australasiæ*, and *Rhizobius ventralis* against San Jose scale.

COQUILLETT, D. W.—Report on the Australian insects sent by Albert Koebele to Ellwood Cooper and B. M. Lelong. Insect Life, Vol. V, p. 251 (April, 1893).

Reports general failure of most of the colonies of *Orcus chalybeus*, *O. australasiæ* and *Leis conformis* sent out by B. M. Lelong.

RILEY, C. V., and L. O. HOWARD.—The California remedy for the San Jose scale. Insect Life, Vol. V, p. 280 (April, 1893).

Describes H. P. Stabler's method of preparing the lime salt and sulphur wash on a large scale.

KOEBELE, ALBERT.—The present status of the recent Australian importations. Insect Life, Vol. VI, p. 26 (November, 1893).

Reports upon the work done by *Orcus chalybeus*, *O. australasiæ*, *Rhizobius ventralis*, *R. debilis*, *R. satellus*, and *Thalpochares coccipliaga*.

KOEBELE, ALBERT.—Studies of parasitic and predaceous insects in New Zealand, Australia, and adjacent islands. [A special bulletin of the U. S. Department of Agriculture], pp. 39 (1893).

Reports success of Rhizobius and Orcus against San Jose scale at points in California. (See pp. 6 and 26.)

EHRHORN, E. M.—Report as horticultural commissioner of Santa Clara County, November 1, 1893. Report California State Board of Horticulture, 1893–94, p. 375 (1894).

States that San Jose scale has almost disappeared as result of work of *Aphelinus fuscipennis* and *Chilocorus bivulnerus*.

COCKERELL, T. D. A.—A check list of the Nearctic Coccidæ. Canadian Entomologist, Vol. XXVI, p. 32 (February, 1894).

San Jose scale is No. 73 in this list.

RILEY, C. V., and L. O. HOWARD.—Quarantine against injurious insects. Insect Life, Vol. VI, p. 207 (February, 1894).

Mentions the occurrence of the San Jose scale at Charlottesville, Va., as an illustration of the necessity for quarantine laws.

SCHWARZ, E. A.—The San Jose scale at Charlottesville, Va. Insect Life, Vol. VI, p. 247 (February, 1894).

An official report describing situation of infested orchard, the plants infested, habits of the scale, and natural enemies.

COQUILLETT, D. W.—The San Jose scale in Virginia. Insect Life, Vol. VI, p. 253 (February, 1894).

An official report describing situation of orchard at Charlottesville, the plants infested, and probable source of infestation.

HOWARD, L. O.—An important enemy to fruit trees. Circular No. 3, 2d series, Div. Entom., 10 pp., 5 figs. (April, 1894).

Eastern occurrences, spread, and remedies.

LAWSON, GEORGE.—A new danger. Chronicle (Halifax, N. S.), April 21 [1894].

Advises careful inspection of nursery stock to guard against importation.

[LELONG, B. M.]—The San Jose scale. Report April (1894) meeting State Horticultural Society, in Pacific Rural Press, May 5, 1894.

"Sovereign remedy" is stated to be the lime-salt-sulphur wash.

RILEY, C. V., and L. O. HOWARD.—The San Jose scale in the East. Insect Life, Vol. VI, p. 286 (May, 1894).

Records the appearance of the San Jose scale at De Funiak Springs, Fla., and in Charles County, Md.

COQUILLETT, D. W.—Preliminary report on suppressing the San Jose scale in Virginia. Insect Life, Vol. VI, p. 324 (May, 1894).
Describes use of gas treatment.

SMITH, JOHN B.—The San Jose scale. Entom. News, Vol. V, pp. 182–184 (June, 1894).
Infested localities in New Jersey.

SMITH, JOHN B.—The San Jose scale. Garden and Forest, Vol. VII, p. 344 (August, 1894). 1 fig.
Calls attention to the danger from infested California fruit.

RILEY, C. V.—Report of the Entomologist for 1893 (1894), pp. 215–221, Pl. I, fig. 1.
A general account, including Eastern occurrences.

RILEY, C. V., and L. O. HOWARD.—The San Jose or pernicious scale. Insect Life, Vol. VI, p. 360, figs. 26–29 (September, 1894).
Previous investigations; sudden appearance in the East; appearance of infested trees; natural enemies at Charlottesville; how distributed; destruction of the scale elsewhere.

RILEY, C. V.—Proc. American Association Adv. Science, Vol. XLIII, p. 229 (1893). (Published, October, 1894.) Discovery of the San Jose scale in Virginia.

HOWARD, L. O.—The Eastern occurrences of the San Jose scale. Insect Life, Vol. VII, p. 153 (October, 1894).
Records the appearance of the scale at points in Florida, Virginia, Maryland, Indiana, Pennsylvania, and New Jersey, and discusses remedial work.

SMITH, JOHN B.—The San Jose scale in New Jersey. Insect Life, Vol. VII, p. 163 (October, 1894).
Discusses source and spread of infestation, varieties of trees affected, and remedies.

ALDRICH, J. M.—Notes on the insects of north Idaho. Insect Life, Vol. VII, p. 201 (October, 1894).
Notes the appearance of the San Jose scale about Lewiston.

COCKERELL, T. D. A.—Notes from New Mexico. Insect Life, Vol. VII, p. 207 (October, 1894).
States that the San Jose scale is well established in the Mesilla Valley.

SIRRINE, F. A.—The pernicious scale on Long Island. Garden and Forest, Vol. VII, p. 449 (November, 1894).
Mere record of finding the scale on Long Island.

SMITH, JOHN B.—The San Jose scale in New Jersey. Bulletin 106, N. J. Experiment Station, pp. 24, figs. 5 (November, 1894).
Occurrence in New Jersey, also general account, including natural enemies and remedies.

LINTNER, J. A.—The "San Jose scale." Albany Evening Journal, November 7, 1894.
Observed at Kinderhook, N. Y.

HOWARD, L. O.—On the geographical distribution of some common scale insects. Canadian Entomologist, Vol. XXVI, p. 353 (December, 1894).
Treats, among other scale insects, of the distribution of the San Jose.

LINTNER, J. A.—The San Jose scale. Rural New Yorker, Vol. LIII, p. 791, 2 figs. (December, 1894).
Neglected on Long Island.

THORNE, CHAS. E., and F. M. WEBSTER.—The San Jose scale. Ohio Exp. Station Emergency Poster Supplement to Bulletin 56, 5 figs. (December, ? 1894).

FLETCHER, JAMES.—Evidence before Committee on Agriculture, 1894, p. 19.
Occurrence in British Columbia.

FLETCHER, JAMES.—The San Jose scale. Twenty-fifth annual report Entomological Society, Ontario, (1894), pp. 73–76, 1 fig.
Occurrence in British Columbia; description; remedies.

SMITH, JOHN B.—The San Jose scale. Report Entomological Department, New Jersey Agricultural College Experiment Station for 1894 (1895), pp. 478–494.
Reprint, with slight additions, of Bull. 106, New Jersey Agricultural Experiment Station.

WEBSTER, F. M.—The San Jose scale. Bulletin 56, Ohio Experiment Station for December, 1894 (January, ? 1895), pp. 18, 5 figs.
Ohio occurrences; New Jersey Bulletin 106 quoted.

SLINGERLAND, M. V.—Danger of spreading the San Jose scale. Rural New Yorker, Vol. LIV, p. 5 (January, 1895).
Eastern localities and prospects.

FOX, CYRUS T., and THOS. J. EDGE.—The San Jose scale. Circular, Pennsylvania State Board of Agriculture, January 23, 1895.
Reports appearance in Pennsylvania. Remedies quoted from L. O. Howard and J. B. Smith.

HOWARD, L. O.—Further notes on the San Jose scale. Insect Life, Vol. VII, p. 283 (March, 1895). Also separate.
Notes additional localities; describes life history of the insect; records certain parasites and new facts as to origin, possible future spread, and discusses remedies.

HOWARD, L. O.—Injurious insects and commerce. Insect Life, Vol. VII, p. 333, (March, 1895).
Incidentally mentions the San Jose scale as an injurious species spread by commerce.

HOWARD, L. O.—Scale insects of Arizona (note). Insect Life, Vol. VII, p. 359 (March, 1895).
States, on the authority of J. W. Toumey, that the San Jose scale occurs in Arizona.

HOWARD, L. O.—New food-plant for the San Jose scale. Insect Life, Vol. VII, p. 360 (March, 1895).
Records receipt from A. J. Cook of specimens of the San Jose scale upon Loquat (*Photinia japonica*).

[COLLINGWOOD], H. W.—The San Jose scale in New Jersey. Rural New Yorker, Vol. LIV, p. 167 (March, 1895).
Observations at Lovett Co. nurseries and Parsons Nursery on Long Island. (See also l. c., p. 317, brief note.)

[COLLIER, PETER?].—The San Jose or pernicious scale. Bulletin 87, new series, New York Agricultural Experiment Station (Geneva, N. Y.), pp. 10 (March, 1895), 2 figs.
Treats briefly introduction and spread; life history; food-plants; remedies.

RILEY, C. V.—The San Jose scale. Bulletin 32, Maryland Agricultural Experiment Station (April, 1895), 6 figs.
Past history; occurrences in Atlantic States; life history; mode of spread; preventive measures; remedies.

DAVIS, G. C., and L. R. TAFT.—The San Jose scale. Pests of orchard and garden. Bulletin 121, Michigan Agricultural Experiment Station, pp. 36–38, Pl. I (April, 1895).
How introduced; brief description; remedies.

LINTNER, J. A.—The San Jose scale. Bulletin N. Y. State Museum, Vol. III, No. 13, pp. 275–303, Pl. V–VII (April, 1895).
Eastern occurrences; life history; food plants; proposed legislation; bibliography.

[WHITEHEAD, THOS.]—The San Jose scale. Richmond Times, April 7, 1895; 3 figs.
Occurrence in Virginia; description (quoted from J. B. Smith); recommendations.

HOFFMAN, J.—The San Jose scale. The Student (Tuskegee, Ala.), April 26, 1895.
Appearance in Alabama; brief description; remedies.

"RATHER PERPLEXED" [pseud.].—The perplexed farmer and the San Jose scale. Southwestern Farm and Orchard (May, 1895).
Can not reconcile different remedies recommended for California and the East.

SMITH, JOHN B.—The San Jose scale. Entom. News, Vol. VI, pp. 153–157 (May, 1895).
Operations against, in New Jersey nurseries.

BECKWITH, M. H.—The San Jose scale insect in Delaware. Bull. 25, Delaware College Agric. Experiment Station, p. 8 (May, 1895).
First noticed near Felton, Del.; how introduced; how spread; remedies, figs. 4.

TOUMEY, J. W.—The San Jose scale. Notes on scale insects in Arizona, Bulletin 14, Arizona Agricultural Experiment Station, pp. 32–47 (June 1, 1895), 5 figs.
Description; how spread; food-plants in Arizona; natural enemies; remedies.

MARLATT, C. L.—Experiments with winter washes against the San Jose scale, season of 1894–95. Insect Life, Vol. VII, pp. 365–374 (July, 1895).
Describes in detail elaborate experiments conducted in orchard of E. Dows, Riverside, Md.

COCKERELL, T. D. A.—San Jose scale. New Mexican (July 11, 1895).
Description of the scale; points infested; whence derived; what to do.

ROLFS, P. H.—The San Jose scale. Bull. 29, Florida Agric. Expt. Station, 19 pp. (August, 1895).
General discussion, including method of introduction, how spread, and remedies, 4 figs.

FERNALD, C. H.—The San Jose scale. Mass. Crop Report, August, 1895, p. 23, 5 figs.
Occurrences in Massachusetts; food-plants; how distributed; remedies.

WEBSTER, F. M.—The San Jose scale. Annual Report of the American Association of Nurserymen, 1895. (See also discussion of this paper.)
General review of the San Jose scale question, with especial reference to the part taken by nurseries in the distribution of the insect and their attitude toward remedial work recommended.

MASKELL, W. M.—*Aspidiotus perniciosus* Comstock, and *Aonidia fusca* Maskell. A question of identity or variation. Canadian Entomologist, p. 14 (January, 1896).
Judging by all external characters (except that of second pellicle), *Aonidia fusca* is different from *Aspidiotus perniciosus*, but a careful comparison of the adult female insects shows that, with the exception of size, their characters are very similar.

[EDITORIAL.]—The San Jose scale in New Jersey. Garden and Forest, p. 41 (January 29, 1896).
Mentions paper by Charles Parry, read at meeting New Jersey Horticultural Society, in which he describes spread of the scale in the State and urges importation of predaceous enemies.